Science and Religion

J. Arthur Thomson

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BEING THE MORSE LECTURES
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BY

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PREFACE

This volume contains six lectures delivered in Union Theological Seminary, New York, in 1924 on the Morse Foundation. I have to thank the Trustees and the Faculty for the opportunity they gave me and for their tolerance in leaving me quite unfettered. In particular I wish to thank President Arthur C. McGiffert, D.D., for his great kindness to me during my visit.

The lectures are published almost precisely as they were spoken, and that may explain a certain insistence of style which seemed natural at the time. They are not meant for the learned, but rather for those who are learning; they were primarily addressed to the students attending the famous Seminary. My aim has been to show with concreteness and circumstantiality that modern scientific formulation in terms of the Lowest Common Denominators cannot be regarded as antithetic to religious interpretation in terms of the Greatest Common Measure. It is along this line that a synthesis must be sought.

To give a connected background to the second and third chapters I have included three Appendices:

(1) On Relativity, (2) on the Quantum Theory, and (3) on States of Matter, for which I am indebted to my youngest son, David Landsborough Thomson, M.A., B.Sc.

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University of Aberdeen,
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The So-Called Conflict Should Cease

EVERY one feels the need of coming to some clear conclusion in regard to the relations between science and religion—two activities or expressions of the developing spirit of man which count practically for more than any others. The long-drawn-out discussion testifies to man's deep desire to reach a unified outlook. He wishes to be consistent, to see life whole, religiously and æsthetically and philosophically, as well as scientifically. Mr. A. D. White's *History of the Warfare Between Science and Theology* has passed through at least fifteen editions, and that people should continue to be interested in a serious discussion of this kind is no bad sign. Yet it may be doubted if the prolonged and wide-spread interest is all to the good. The religious mind becomes involved in polemical argument when it might be better employed studying a little science at first

hand; and the scientific man sharpens his dialectic weapons when he might be better occupied in religious discipline. There is apt to be a wastage of time and energy, a distraction from problems which are more real.

The aim of this introductory chapter is to show that an opposition between scientific description and religious interpretation is fundamentally a false antithesis. The aims and moods are quite different, and there is no justification for what has been called "warfare" or "conflict." Disputes may be ended by accepting the arbitration of a frontier commission. We must learn to render unto Science the tribute that is its due; and to God the things that are HIS.

The Aims and Methods of Science

A good definition of science is given by Doctor W. Trotter in his *Instincts of the Herd*—"a body of knowledge derived from experience of its material, and co-ordinated so that it shall be useful in forecasting and, if possible, directing the future behaviour of that material." But this does not bring out the point that "knowledge derived from experience of its material" is not exclusively scientific knowledge. We come to know a friend, a dog, a country partly by feeling and by activity, as well as by scientific analysis. So we must amend the definition. Science is a kind of knowledge reached by recognised methods of observation and experiment,

registration and measurement. It limits itself by its own methods, and though it is not confined to the study of the ponderable (for that would mean excluding psychology and sociology at the very least), it always depends for stability on some kind of measurement or registration. So it may be said that Science includes all systematised, verifiable, and communicable knowledge, reached by reflection on the impersonal data of observation and experiment. We mean by "systematised" that science is co-ordinated knowledge. The multitudinous data are only the raw materials; science is the formulation of these in empirical terms. We mean by 'verifiable' that its conclusions can be checked by all normally constituted minds when the observations or experiments are repeated with strict adherence to scientific methods. Of course the checking demands a modicum of competence. We must be able to speak and read the scientific language; we must be able to use the scientific tools. It is not given to all of us to verify Einstein's theory of relativity.

It must not be supposed, however, that a hard and fast line can be drawn between the domain of established exact science and what is mixed or inexact science—still half-conquered territory. In most departments of science there is a penumbra, a zone between light and shade. Thus a good deal of so-called "psychic science," if not the whole of it, is still penumbral. It must also be borne in mind that

the various sciences cannot be expected to reach the same level of precision. The more complex the material, the more approximate will be the formulation. It is easier to make mistakes with statistics than with weighing things in a balance. The data of biology and psychology are not measurable to the same degree of accuracy as those of chemistry and physics. One may take three observations of a comet and three of a cat, but it is safer to predict the date of the comet's return than to tell how the cat will jump. It is no reproach to biology and psychology and sociology to call them "inexact" sciences; they are limited by the complexity of their material and by the emergence of such "imponderables" as intelligence. In many fields these inexact sciences are becoming very exact, as in the study of Mendelian inheritance and in experimental psychology. In proportion to the attainment of exactness there grows the possibility of prophecy—of being wise before the event. In our present study we are confining attention to the *concrete* descriptive sciences like chemistry and physics, biology and psychology, leaving out those like mathematics, statistics, and logic, which are methodological—means rather than ends.

Laws of Nature

What science aims at is the discovery of laws or general formulæ which will enable us to say: "If this, then that." These laws are short-hand descrip-

tive formulæ, summing up the routine of our experience. "We must confess," said Professor J. H. Poynting, "that physical laws have greatly fallen off in dignity. No long time ago they were quite commonly described as the Fixed Laws of Nature, and were supposed sufficient in themselves to govern the universe. Now we can only assign to them the humble rank of mere descriptions, often erroneous, of similarities which we believe we have observed." (Address, Section A, Report British Association for 1889, p. 616.)

The older, less clear-headed view of science was that it *explained* things; the modern view is that science offers descriptive formulæ. The change may be said to date from Kirchhoff's definition of mechanics as the science of motion, whose object it is "to describe completely and in the simplest manner the motions that occur in Nature."

Science aims at describing coexistences and sequences as tersely, simply, exhaustively, and consistently as possible; and the so-called "explanations" that science gives do not amount to more than saying something like this: "These observed sequences which seem puzzling are particular cases of chemical law No. 5 and physical law No. 7." Or, again, "This interesting fitness in the bird's wing is a good instance of the outcome of long-continued Variation and Selection."

We are accepting, then, the modern view that the

aim of science is *descriptive;* and this indicates at once why it cannot clash fundamentally with religious interpretation; but there are several saving-clauses which must be borne in mind if we are to avoid false simplicity.

Scientific Analysis

Science aims at reaching thought-economising descriptive formulæ, such as the Law of Gravitation, whether Newton's or Einstein's. But, in order to state these laws in their simplest form, it is necessary to subject the data to penetrating analysis. Thus, much of the work of science consists in reducing the data to their lowest common denominator. The animal is analysed down to its living cells with their colloidal protoplasm. The inheritance is analysed into a bundle of hereditary "factors" or "determinants." Behaviour is analysed into an intricate medley of "urges," "obligatory reactions," "instincts," "habits," "intelligent adjustments," and so on. The crystal is analysed into its molecules, these into atoms, and these into electrons and protons. The meaning of these terms will be explained later on. The chemical reaction is analysed into a dance of molecules in which there is an orderly changing of partners. Our point is that when we say that science furnishes descriptive formulæ, we must be perfectly clear that there has been a preliminary reduction of the fractions of reality to their lowest terms. In

this characteristic analysis there is often a risk of some fraction of reality being lost sight of. Thus the analysis of animal behaviour sometimes leaves out the "mind."

Science in Part Historical

A second saving-clause is this. Science aims at giving the tersest, yet completest, description of a routine of events. "The law of gravitation is a brief description of *how* every particle of matter in the universe is altering its motion with reference to every other particle" (Karl Pearson, *Grammar of Science*, ed. 1900, p. 99). But this is not quite all, for the world is not static, but in flux. The scientific account must therefore in all appropriate cases include historical or genetic description. Science has to describe the genesis of the solar system and the earth, the evolution of organisms, and the history of man and his institutions. And this historical description must be more than a *modal* formulation of the stages by which a given result has been reached; it must be, as far as possible, a *causal* formulation of the factors operative in the process.

The Scientific "Why"

The third saving-clause has especially to do with biological, psychological, and sociological generalisations. For there, when one thinks of it, the formulation must do more than is required in the domain

of chemistry and physics. In the sciences which have to recognise the emergence of 'life' and 'mind,' the question 'why' *must* crop up even for the scientific inquirer. In chemistry and physics he feels no need for asking more than 'How' and 'Whence.'

Let us take an illustration. A cat is excited by a threatened assault on the part of an obtrusive dog. Its hair stands on end, it arches up its back, its tail stiffens, its eyes shoot fire, it appears much above its usual size—and the dog sooner or later finds it convenient to remember that he has an engagement somewhere else. Now we know a great deal about the "How" of this familiar bio-psychological phenomenon. The cat is nervously and emotionally excited. We do not suppose that it is afraid, but its dignity is offended and it is very angry. The emotion is associated with a nervous thrill passing by the sympathetic nervous system to the suprarenal body, which increases its secretion of adrenalin. This chemical messenger is swept away by the blood, and all sorts of effects immediately follow—a change in blood pressure, an increase of the sugar content, a toning up of the muscles, including a stimulation of the very minute ones which erect the hair. So the hair stands on end. We can give a provisionally good answer to the question "how does all this happen?"—and that question 'how' must always be pressed. But our description is unsatisfying unless we can say something in answer to the question

'Why.' The cat does not deliberately do it and yet it does not do it for fun. The reaction is adaptive. When purposiveness enters, science *must* ask 'why' as well as 'how.' But it is a scientific, not a transcendental 'Why.' It does not raise any question as to the ultimate significance of events, but it inquires into utility.

In What Sense Does Science Explain?

We see then that the work of science is to formulate laws. In so doing, it must first try to reduce things to their lowest terms; it also seeks to give historical descriptions; and biological, psychological, and sociological generalisations may also fail in completeness unless they tell us *why* this or that event occurred. But in all this there is no attempt at an interpretation of the world.

Does science explain anything? It explains only by saying: This occurrence is a particular case of a general law; This strange phenomenon may be brought into line with others that we are familiar with; This result is the outcome of a long series of antecedent stages; or This animate behaviour is justified by some degree of purposiveness. In these ways science explains, but not in any other way.

The Scientific Questions

In regard to anything and everything to which its methods can be applied, Science asks four questions:

(1) *What is this*—as a whole and in all its parts, intact and analysed, as a visible thing and in its underlying invisibilities?

(2) *How does this behave*—as a whole and in all its parts, intact and analysed, as a visible thing and in its underlying invisibilities; how does it persist if it is at rest; how does it keep agoing if it is active; how does it remain the same and how does it change?

(3) *Whence came this;* what has been its history? If it be a living creature, by what stages did it develop as an individual, and by what stages did it evolve as a member of a race?

(4) *How did it come to be as it is;* what factors have been operative in its genesis, development, evolution, or history? What were or are the pre-conditions of its emergence?

In short, there is a morphology, a physiology, a geneology, and an ætiology of everything that can be scientifically tackled.

Such are the scientific questions—'What,' 'How,' 'Whence,' and again 'How.' But science never asks: What is the meaning and value of this? What is behind it all? How is this scientific knowledge of things related to other constituents of our experience? Science works towards a cosmography; to grope after a cosmology is not its *métier*. Our point is

that if the difference between empirical description and religious interpretation were kept clearly in mind in both camps—not that there should be two camps—there would be less talk of the conflict between science and religion. Now let us go a step further.

Limitations of Science

It is often supposed by the uncritical that science gives a *full* account of things. But that is in many cases impossible. It is a large assumption that we exhaust any object of sense-experience by the sensory organs we have at our disposal or by the instruments which increase their scope and precision. We shall return in Lecture II to our peep-hole direct knowledge of the world.

When science is most perfect, as in gravitational astronomy and in mechanics generally, it is possible to make predictions which are fulfilled. This shows that in such cases our scientific analyses and formulations have approximated closely to reality, otherwise the prophecy would not have come true. On a few data Halley prophesied the return of his comet, and it appeared to a day; but Halley would have been the first to disclaim any knowledge of, let us say, the chemistry of the comet or the true inwardness of gravitation. Science always knows in part and prophesies in part. Its method is by abstraction; that is to say, it seeks to focus attention on cer-

tain aspects or properties at a time. The geologist does not as such leave any room for the *beauty* of the scenery, yet the fact of beauty may be as real a part of his experience as a knowledge of petrography.

Another limitation of science is that it must work with descriptive "counters" that are not self-explanatory. The biologist's counters are "life," the "organism," the "cell," "protoplasm," and so on. How difficult they all are! Of recent years, as we shall see, the physicists have been reducing the number of their "counters" at a great rate, and almost the only one left is electricity, but how big it is with mystery! Electrons and protons are at present the "irreducibles"; we have to take them as given.

Another limitation has to do with beginnings. It is quite legitimate for the biologist to say: I take initial primitive organisms as given. Perhaps this is at present the wisest thing to do, for biology does not do more than hint at the way in which even the simplest living creatures may have come into being. Science is very vague in regard to most beginnings. And yet it is usually the first step that counts.

A salutary change in the scientific outlook is marked by the modern use of the term 'emergence.' It is distinctive of evolution that from age to age there is a succession of "newnesses"—not merely new patterns, but embodiments, as it were, of new ideas. As Bergson has rightly insisted, evolution is characteristically *creative*. New ideas emerge—now

an insect and again a bird, now a moss and again a flower, now a seed-bearing plant and again a mammal, now an elephant and then a man. Nothing is clearer to the zoologist than that birds arose from an extinct reptilian stock, but he cannot give much content to his answer to the question, *How*. He cannot even make it clear to himself how his Silver Wyandottes and Rhode Island Reds sprang from the Wild Jungle Fowl of the Indian woods. They evolved, they emerged; but always the resultant seems too large for the components. A new relatedness has come about. Out of two gases—hydrogen and oxygen—there is produced under certain conditions a new thing—water, whose remarkable properties cannot be readily accounted for even by the highly developed chemistry of to-day. Out of the beggarly elements of water, earth, and air, the chemist builds up a food or a poison, a life-destroying explosive or a life-saving medicine. Out of the extinct reptiles there emerged the conquerors of the air. From humdrum parentage there emerges a genius. God said, "Let Newton be," and all was light. In the field of mechanics we can say with a clear intellectual conscience—*Causa æquat effectum;* but only in that sphere. Two motions become a third motion—the same motion changed in direction. No doubt there is the same continuity in other spheres, but we are not able to follow the nexus. Nothing alien or magical intervenes when the novel emerges,

but the scientific unravelling of the chain of causes is still very limited. Sometimes, as in the big lifts in organic evolution, such as the appearance of intelligent behaviour, social sympathy, conscious individuality, and personality, we are justified in saying that a new aspect of reality has been revealed. In any case, the most complex sciences have to do with emergences rather than with resultants, with new syntheses rather than additive summations. This is one of the luminous ideas in Professor Lloyd Morgan's *Emergent Evolution* (1923).

Religion

It is easier to speak about science than about religion, for science is essentially impersonal, while religion is essentially personal. Religion has to do with an aspect of reality that is beyond science. In modern times it should include an interpretation of the results of science, but that is a recent development. Religion is difficult to define, for three reasons. First, because it is like a flower, which ceases to be when science anatomises it. Is it not almost a contradiction in terms to give a scientific definition of religion? Second, religion is one of the expressions of the developing human spirit, and it has taken many forms in different ages and among different peoples. It has evolved and it is evolving still. Third, religion is essentially personal, and expresses itself differently in different personalities. It is more intel-

lectual in an Aquinas or a Spinoza, more emotional in a Saint Bernard or a Saint Francis, more practical in a Luther or a Knox. Sometimes a man does not know how intensely religious his brother is. But there has always been in religion—whether predominantly practical, emotional, or intellectual—a recognition of a higher order of reality than that reached in ordinary experience. With ordinary vision the young man in the ancient story saw what are sometimes called "the facts of the case"—the beleaguering hosts and Israel's poor chance; but he looked again, and saw, beyond all that—"the chariots of God and the horsemen thereof." That was religious vision.

Perhaps the common feature in all religious activity is that man sends intellectual, emotional, or practical tendrils into the unknown, into "the beyond," into the super-sensuous, into the divine. Its essence is also threefold—submission to the Divine Will, some form of communion with the Divine, and a vision of God. It is a seeking after God which may be sometimes more than a facile finding. Religious experience comes easily to some natures—like the opening of eyes to the sun. But to others it comes with difficulty—only after they have strained at the end of the practical, emotional, or intellectual tether of everyday experience. For these are the three chief pathways by which men become religious. Let us dwell for a little on the three portals, for they

throw light on the relations between science and religion.

The Practical Pathway to Religion

Some clearness is introduced into a study of the old chapters in the history of religion, and into a survey of the religions of uncivilised or simple peoples to-day, if we recognise the idea of the three portals or pathways. In the days of the childhood of religions, man was often baffled by the Forces of Nature in a way that we cannot even imagine. We have a thousand victories behind us, while he had almost none; we have come to understand a good deal about the powers of the world, to him all was obscure; moreover, we have in recent years a new mood of non-submission. "Nature," as we say, sometimes seems to gather itself against man—in cyclone and earthquake, in famine and pestilence, saying to him "You must Die"; but in modern times man does not hesitate in hurling back the defiant answer: "Nay, but I shall live." On every line, the days of folded hands are over. Man is man, and master of his fate.

In old days, man was fighting for his foothold. Beasts of prey he could understand, and he was no coward. But the blizzard, the drought, the earthquake, the flood, the tempest, the volcano, how helpless he was against these. He was afraid; he invested them with intention, if not with personality; he tried

to placate them with offerings. Thus arose the old religions of fear and of self-preservation. Perhaps we understand them best when we think of early man as often desperate—clutching like a drowning man at straws. It was at any rate an off-chance that a sacrifice might be acceptable, that a supplication would be heard, that a charm would work; and so they were tried. We shall return to this historical point of view in connection with psychology, but meanwhile we need only notice that in some religions of to-day, as in some African negro tribes, the idea of the Creator is vague and distant compared with the vivid realisation of the spirits of the mountain, of the waterfall, and of disease, which are for practical purposes much more important. In a few cases, authorities tell us, there seems to be no worship of the dim and distant Creator, but an appeal is made to the more immediately present spirits.

When the hero of Victor Hugo's *Toilers of the Sea* had done everything that his wits could devise and his energy could achieve, he was balked, "by the hand of God," as lawyers say; and it was at this juncture that the novelist with true psychological insight makes his hard-shelled and stiff-necked hero fall down on his knees and *pray*. This was true to human nature. At the end of his practical tether, when he has done all he can and has failed, many a man has become religious—especially in bygone times.

It is plain, however, that this pathway must cease to be trodden as it used to be, for man has attained to a mastery of Nature which makes much of the ancient despair, prayer, or fear-sacrifice quite unnecessary. Moreover, a well-educated modern man has a conception of the Order of Nature which forbids him expecting or wishing any providential intervention for his own sake. We may pray for peace, if only since part of the answer comes in the asking; but we do not any longer pray for rain. The more it is given to man to attain, through science, to a mastery of things and to a control of life, the less likely is he to become religious along the practical pathway.

It should be remembered, however, that there are practical endeavours which are concerned neither with bread and butter nor with health and wealth. There is the ethical life. There are evil spirits to be expelled; there are moral battles to be fought; there are adventures of the spirit. Yet here also it must be admitted that the mood of the time makes us strain as long as we can at our tether. We incline to give all the non-religious means the first trial; we prefer Couéism to conversion. This may be unwise, but it is human nature.

The Emotional Pathway

The second pathway or portal by which at all times men have entered into a religious life has been

that of emotional stress. In great joy, or in great sorrow, or surcharged with æsthetic emotion before the beauty and wonder of Nature, men have often become religious. There are crises which are too much for flesh and blood to stand; the pathos of human life demands an infinite pity. Or again it may be that the cup of joy runs over, and then man says: "Give thanks unto the Lord for He is good, His mercy endureth for ever"; or "I have seen the goodness of God in the land of the living"; or "I shall dwell in the House of the Lord." As William Blake said: "I'm in God's presence, night and day; He never turns His face away."

This emotional pathway to religion is oftener followed by modern man than the practical pathway. But it does not lead to religious experience until there is intense emotional strain, and that is often relieved in art, especially in music, with its unique power of expressing the inexpressible. It is plain that when the religious life has been entered upon, the transcendental light may be shed on everyday emotional and æsthetic experiences, and reflected back again; but we are thinking just now of intense emotion as a *pathway* to religion, as is illustrated in the case of those who have an unusual experience of the beauty of Nature, men like Wordsworth and Ruskin; or in the case of some of the Hebrew poets, like the author of the Book of Job. There does not seem to be any reason why this portal to religion

should ever be closed by science, but we cannot shut our eyes to the fact that in so far as Nature is the subject of scientific inquiry the mood and method of that inquiry will not in itself be favourable to the growth of emotional delight. The mood of science is cold and unemotional.

There are some who take up the position that everything there is to be got out of Nature can be reached by scientific inquiry, who thereby shut one of the old-fashioned portals to religion. This consequence cannot indeed be used as an argument against the view that Science has the last and only word for the sojourner with Nature. That view must not be judged by any consequences that its acceptance would involve; it must be judged on its own merits—which are slender, and in the light of the positive experiences enjoyed by those who have found that there is a right of way called "Feeling for Nature." Artists, of course, only smile at the scientist's trespass notices.

The Intellectual Pathway

The third pathway or portal to religion is that of the baffled intellect. Primitive man was not troubled with many metaphysical problems, except the eternal 'whence' and 'whither.' He was more perplexed, we may believe, with the agency of powers which he did not see or could not understand—the stroke of lightning, the earthquake, the plague. He must also

have been puzzled by anomalies. Every one seemed to die, yet here was a King whom they remembered when they were boys—he did not seem to show any signs of weakness. He must have a charmed life—Mana. Can others attain to it?

This dying was a strange matter, especially when it came suddenly—the strong man of yesterday is dead to-day, yet no wild beast has rent him. Is there no charm by which such tragedy can be evaded? We must remember how very modern is the idea of disease as a natural process, how very recent is the theory of microbic diseases, and how neither Darwin nor Pasteur had more than a glimpse of the part that insects play in the dissemination of plague and pestilence. One of our commonest maladies, what do we call it but "the influence," and a not uncommon end to life we call "a stroke." Our words recall the outlook of our ancestors.

To the simple mind, birth was hardly less perplexing than death. We have now swung to the opposite extreme and have sunk to a commonplaceness of view which is almost worse than the savage's clouded vision.

The inexplicable, the apparently anomalous, the terrific, what could primitive man do but people the world with spirits—both malign and benignant—who were the causes of events that puzzled him? And after stages of polydæmonism, perhaps of polytheism, there emerged the idea of a great God who

used the Forces of Nature to reward and to punish his children.

But science has shown the order and unity of the world; it has depersonalised the Forces of Nature and Nature itself; it has put the Laws of Nature in their proper place; it has made the world one; it has shown how things have grown and how living creatures have evolved. The greatest change of all is in the growth of the modern scientific mood, which forbids us eking out our scientific formulations by transcendental factors.

This point is crucial, and it has been admirably put by Doctor G. J. Blewett in his striking book, *The Study of Nature and the Vision of God* (Toronto, 1907), where he exposes the positive danger of searching for some weak spot in the scientific scheme and saying: "Here at any rate you must admit the need for God."

"One of the attempts to get past the scientific position is so fundamentally bad as to deserve special mention—the endeavour to justify belief in God by seeking to find gaps in the continuity of Nature. It is true that a God thus made manifest—made manifest not by the greatness and harmony of Nature, not by its abiding law and continuous order, but by its rents and gaps—would be no worthy object of religious devotion. But that is only the beginning of the matter. Once you shatter the continuity of Nature, you shatter more than Materialism. You

shatter the possibility of all science whatever. . . . You open up the gulf of universal scepticism, and Materialism disappears, it is true, but along with it disappear Theism and Theology and the rational basis of every sort of religion except two, between which men will continue to choose according to their individual dispositions—stoicism (as a practical temper, not as a philosophy) and Epicureanism."

"In a word, in insisting on the continuity of Nature men of science have been better theologians than the theologians themselves. If God exists at all, He is the God of all Nature and of every Natural law. There are no gaps in His workmanship, no breaches of continuity in His activity. Nature is an activity of His, and every natural law is a principle of that activity. If the theologians would be true to theology, what they have to do is to protest, not against the principle of continuity, but against too narrow a reading of it and too narrow an application of it to reality. The principle of continuity is unworthily treated if it is limited to certain physical and chemical processes. The true field of the principle of continuity is the total history in time, the total evolution of the universe. And so viewed, it is simply one way of apprehending the essential rationality of God and of the divine action in Nature and in history."

What then is true to-day of the intellectual approach to religion? It remains widely open. There is the fundamental mysteriousness of Nature. What

is behind and what was before the irreducibles—such as the electrons and protons? What is the significance of the long-drawn-out history, continuing sublimely for millions of years, and including Man not as an episode, but as a climax, which looks as if it were aimed at and prepared for? Man! who can weigh the heavens in a balance and count not only the stars but the electrons that compose them. Man! who thinks about God and worships Him, sometimes unafraid. When the half-Gods go, the God arrives!

Looking backward, we see that the pathways to religion that were open long ago are open to-day, though not exactly as they used to be. At the limit of our practical tether as concerns the works of our hands, we may possibly be religious. Thus, we may pray. But our prayer is rather "Thy will be done," than that there should be intervention to favour us in our individual endeavours. In the field of ethical endeavour, however, the pathway remains widely open, though only fools can pray to be delivered from bad temper while continuing a habit of life which promotes dyspepsia. We must be open-eyed with our religion.

The emotional pathway remains open, especially perhaps to those who are susceptible to the wonder and beauty of Nature.

The third portal remains open, but the tether on which we strain is much longer than that which

limited our forefathers, and many of our problems are such as science can never solve.

Our Limitations Do not Prove the Validity of Religious Solutions

Those who are not sympathetic to the line of thought indicated in this chapter may justly point out that the existence of strain-limits to our practical, emotional, and intellectual activities does not prove that there are religious solutions available or useful. But our immediate object is simply to indicate that in bygone days men who have followed these pathways have often reached a Vision of God. It shone upon them as they journeyed, as on Saint Paul on the way to Damascus. The heavenly vision is not indeed the *necessary* reward of straining thews and sinews to the limit of endurance, nor of rejoicing in beauty, nor of never ceasing to ask "Whence?" and "Whither?"—to many the vision never comes, even to the noblest. To others it comes happily as part of their inheritance, which they question as little as their parentage. Our point is that if the Heavenly Vision comes—finding us on different journeyings, and seeming very different to different eyes—then we may be assured that it will not do anything but supplement and transfigure the results of Science. Scientific concepts are empirical; religious concepts are transcendental.

The highest religious concept is God—"the crea-

tive source of all evolution," "the divine spirit that animates all," "the nisus directive of the course of events," "the directive Activity on whom the manner of going in all natural events ultimately depends"—these are a few modern expressions of man's never-more-than-groping thought, which, however, the Christian Religion has revealed to many. What we are concerned with here is the conclusion that science as such has nothing to say to this highest of all concepts. The idea of God is outside the scientific universe of discourse.

The extreme positivistic position maintains that there is no real knowledge except that reached by scientific rules and method. Personally we regard this as a modern superstition, for we are convinced of the reality of the Beauty of Animate Nature, and we cannot but recognise that the imagining of transcendentals has justified itself in some of the finest things men have done.

No Antithesis Between Scientific Description and Religious Interpretation

If we refuse the Positivist dogma, then it becomes clear that in essence there can be neither alternative nor antithesis between a scientific and a religious view of the world and man's place in it. We may have neither—which means impoverishment of spirit; or we may have one of the two; but we may have both. It is open to the student of science to say

that he does not himself see any heavenly vision, nor any light save that which is always shining on land and sea; but what he has no right to say is: "You must choose between the scientific and the religious view of nature and man." Similarly, it is not open to the religious-minded to say: "God or Natural Selection," or to offer as logical opposites "The Bible or Darwinism." We absolutely refuse to admit the legitimacy of any alternative between the empirical and the transcendental, between the empirical Least Common Denominator and the transcendental Greatest Common Measure. It is a little like asking "Will you have air to breathe or food to eat?"

No Idea-Tight Compartments

It may be said that we are advocating a return to the old impossible device of trying to maintain idea-tight compartments in the mind—one for science and another for religion; science for week-days, so to speak, and religion on Sunday. But what we plead for is the very opposite—namely, all-around intellectual consistency and fair play. We wish the religious mind to face the results of scientific inquiry, recognising that in so far as they are well-established they cannot be taken or left. They must all be taken; but it does not follow that their supposed implications or generalised expressions need be accepted without criticism. The analytic, genetic, matter-

of-fact methods of science lead to conclusions or formulations which cannot be tampered with. It does not matter in the least whether we like them or not, whether they trouble us or not. All that we dare suggest is that they are necessarily partial and limited; they are abstract; they are restricted to certain fractions of reality which are amenable to scientific methods. There may be other aspects of the realities in question which the scientific methods do not grip. The scientific conclusions may need to be supplemented by other conclusions reached in different ways. Truth is an august word, and, fallible human nature being what it is, there is a risk of mistaking for the truth what are only contributions thereto. Thus in regard to scientific conclusions, we have to ask what relevant contributions—say as to the nature of Man—may be reached along other rights of way. We have also to ask the masters of science not to allow their cosmography to become insidiously a dogmatic cosmology.

Form and Idea

It may be urged, however, that we are proving too much. If science and religion are two complementary activities of the developing human spirit, why has there been a long-drawn-out controversy between them? Is it not proving too much to refer all the friction and bitterness to the attempt to talk two languages at once? The answer is to be found

in a survey of the famous controversies of the past, and this seems to us to show conclusively that most of the friction has been due to one side or the other forgetting its proper aims and methods. If science declares that the mind may be left out of account in describing human activities, or asserts that personality is altogether an affair of the endocrine glands, why, then, the religious mind, not to speak of common sense, must protest. It is open to the modern psychologist or psycho-biologist to say: "This activity of yours which seems to you an expression of your very self is actually the outcome of an enlarged pituitary gland"; but it is not open to him to generalise this order of facts till it fills the whole picture. When we seek to appraise or appreciate a complex like man, we must try to take an all-round view. Similarly, we decline to adopt as more than partial a scientific view of Nature that leaves Beauty out, or that attempts no appreciation of the outcome of the whole evolutionary process—Humanity.

But the fault is not altogether on the scientific side. If the religious mind pins its faith on some particular form of doctrine, which trenches on the concrete, it may be wrapping up a truth in a form which is an insult to the modern scientific intelligence. There is doubtless spiritual truth in the Genesis account of the origin of Man; but to take it literally robs it of its poetry. As a diagram of what we mean we may refer to the statement of Doctor John Light-

foot, a great Hebrew scholar, one of the Westminster Divines, and once Vice-Chancellor of the University of Cambridge, who goes the length of telling his readers that man was created by the Trinity in the year 4004 B. C., at nine o'clock in the forenoon. When religion condescends to concrete precision in regard to prehistoric processes or unverifiable events, it is not likely to be doing its own case much service.

Similarly, though we speak with diffidence, there is perhaps a spiritual truth in the doctrine of the resurrection of the body. If the major proposition be accepted that the personality persists after death, a proposition before which Science is almost dumb, then we can discern an esoteric truth in the doctrine of the resurrection of the body. For the body plays its part in the development of the personality. But the ordinary presentation of the doctrine is an insult to the scientific intelligence. Generalising, we may say that while the fundamental ideas of religion are unassailable by any scientific attack, the particular form they assume may have to be altered. What was a natural form when the spiritual truth was first perceived, may outlive its legitimacy.

Another fault that has been committed on the side of religion is that of prematurely fixing frontiers beyond which scientific description would not be tolerated. We have alluded to this already in connection with the attempt to find weak spots in the

scientific cosmography. "We grant you," some have said, "the formula of Organic Evolution, but as to the Origin of Life, *that* was a divine influx." "The natural evolution of mammals we grant you, but Man is the great exception. His origin was divine." This view was championed from the scientific side by Darwin's magnanimous colleague, Alfred Russel Wallace, who thought that the facts justified the religious idea of successive spiritual influxes—notably, at the origin of life, at the origin of consciousness, and at the origin of human personality. There are several objections to this device. It jettisons continuity of evolutionary process, to save—*what?* It also includes a somewhat unpleasant suggestion, that the original institution of the Order of Nature was imperfect, and that it became necessary on various subsequent occasions to intervene with special aid to help the evolving world over difficult stiles. Furthermore, there is, if we understand it aright, a suggestion of two worlds, as if God were not behind everything all the time.

But the objection we wish to note here is the undesirability of saying: "Thus far and no further." What seems an impregnable fortress—a Gibraltar that cannot be taken—may be flying the scientific flag a generation afterwards. Not many years ago biologists would have hardly turned their head to listen to an investigator who asserted that he had been able to make sugar by the action of light on

carbon dioxide and water. They were quite sure in the nineteenth century that the touch of life in the green leaf was a *sine qua non* in effecting this wonderful alchemy. Yet the artificial synthesis has been achieved, and who can tell what other steps in the same direction may follow. The whole history of the conflict between science and religion points to the unwisdom of religion defining Rubicons. No one can wish that the religious mind should accept without question every scientific conclusion, for the statement of conclusions is a great art and, beyond the realm of mathematics, demands discipline in metaphysics. Such acquiescence would be evading the duty of philosophical criticism. But what history tells us to avoid is the error of King Canute.

In conclusion we would point to the biggest fact of all, that science has shown the world to be a more harmonious, more unified, in every way grander world than our forefathers wot of; the serious question is whether our vision of God is also growing.

SUMMARY

(1) A truce in the long-drawn-out conflict between science and religion is overdue, for the opposition is largely based on misunderstanding.

(2) Science is systematised, verifiable, and communicable knowledge reached by reflection on the impersonal data of observation and experiment, registration, and measurement. But it is impossible to draw a hard and fast line between established exact science and mixed science which has not reached the same degree of pre-

cision. The more complex the material, the more approximate will be the formulation.

(3) The Laws of Nature are shorthand descriptive formulæ, summing up the routine of our experience in the simplest possible terms, such as the Law of Gravitation, whether Newton's or Einstein's.

(4) The formulation of these thought-economising laws requires previous analysis, reducing the data to their lowest common denominator, and in this process there is a risk of some fraction of reality being lost sight of.

(5) But the descriptive account which science gives must also be historical or genetic, for the world is in flux, and the account of becoming must be causal as well as modal.

(6) In chemical and physical sciences the questions 'How' and 'Whence' suffice, but in bio-psychological sciences, where we have to deal with purposive individuals, the scientific description is inadequate unless we also ask the question 'Why.' But it is a scientific, not a transcendental, 'Why.' It does not inquire into the ultimate significance of events. There is no attempt at interpretation.

(7) In the strict sense science does not explain anything, except by saying: This occurrence is a particular case of this or that general law; or: This can be reduced to simpler terms; or: This is an outcome of a long series of antecedent stages.

(8) The ordinary questions of science are four: What is this, as a whole and in its parts? How does this work? Whence is this? How has it come to be as it is? But science never inquires into meanings or ultimate purposes.

(9) Science does not profess to give a complete account of things; it aims at a description as complete as our sense-organs and methods of experiment will allow. In applying its methods it has to abstract away certain aspects of things. Science works with irreducible 'counters' such as 'electricity,' 'life,' 'mind,' which are not self-explanatory. Science cannot penetrate to the beginning, before

there were any of its irreducibles. In its historical descriptions, it has to deal not only with resultants but with "emergences," outcrops of new syntheses which must be accepted. Only in the field of mechanics can we say: *Causa æquat effectum.* These are some of the limitations of science, which should be borne in mind in thinking of its relations to religion.

(10) Religion is difficult to define because it is beyond science, because it is essentially personal, because it has had a long evolution, and because it has practical and emotional, as well as intellectual aspects. It has always implied a belief in a higher order of reality than that reached in ordinary experience.

(11) When man strains at the limit of his practical, emotional, and intellectual tethers, he stretches out his hands to a higher order of reality than is reached in ordinary experience. The essence of religion in its higher forms includes submission to the Divine Will, some form of communion with the Divine, and some Vision of God.

(12) The practical pathway to religion is less frequently followed to-day, because Science has given man so much mastery, and because the scientific view of Nature forbids the idea of providential interference. But the pathway remains open to those who take seriously the problems of the ethical life.

(13) The second pathway, to which men are led by overpowering emotion—joyous, tragic, æsthetic—is still open to all. But there are mundane means of finding emotional relief, notably in music, with its unique power of expressing the inexpressible. The Wonder and Beauty of Nature still bring many to the emotional footstool of religion; and science does not interfere with this, except that its mood is characteristically cold and unemotional, or except when it dares to deny to feeling a right of way in the appreciation of Nature.

(14) The third pathway to religion—the pathway from baffled intelligence—is less open to modern man than it

was to his forefathers, for science has banished so many obscurities. Science has disclosed the intelligibility, the order, and the unity of the world; it has de-personalised the Forces of Nature and Nature itself; it has put the Laws of Nature in their proper place; it has shown how things have grown and how living creatures have evolved. The scientific mood has been clarified, and it is realised that empirical descriptions must never be eked out by transcendental factors. The idea of searching for weak spots in the scientific scheme in order to say: "Here at any rate you must admit the need for God," is radically fallacious. But there are unsolved scientific problems without number. The fundamental mysteriousness of Nature remains. The philosophical problems of the beginning and the ending, of meaning and purpose, press upon us still.

(15) The existence of strain at the ends of our practical, emotional, and intellectual tethers does not prove that there are valid religious solutions, but it suggests the naturalness of seeking, as men have always sought, after the vision of the Divine. And the object of our present study is to show that if the Vision of God finds us, it will not be anything but supplementary and transfiguring to the results of science. Scientific concepts are empirical; religious concepts are transcendental.

(16) An extreme positivist position will deny the validity of all knowledge except that reached by scientific rules and methods. But if that position is not held, there can be no fundamental antithesis between a scientific and a religious view of Nature and Man's place in it. The one seeks for the empirical Lowest Common Denominator, the other seeks for the transcendental Greatest Common Measure.

(17) Care must be taken to avoid the fallacy of trying to establish idea-tight compartments in the mind. What is desired is mutual aid from diverse disciplines and an endeavour after all-round intellectual consistency. But scientific cosmography must not insidiously usurp the

place of a cosmology, and religion must never dream that science will allow *it* to call the tune in a description of the universe.

(18) There can be no fundamental antithesis between empirical description and transcendental interpretation, but there may be opposition in form and expression. It is possible for science to err in its formulations and in the expression it gives to them. Thus there can be no religion if we regard the personality of man as a physiological illusion. Similarly, it is possible for religion to err in giving its doctrines a concreteness of form which cannot possibly be accepted by the scientific mind except in some undesirable metaphorical way.

Where difficulties exist in regard to important questions the scientific mind should be careful not to try to close doors which are outside its universe of discourse, and the religious mind should be tolerant, for even the student of science who disagrees with it may be in his own way waiting patiently on the Lord. The religious must ask themselves also whether, with the scientific disclosure of the unity and grandeur of the world, their vision of God is also growing in clearness and majesty.

CHAPTER II

THE UNSEEN UNIVERSE AND THE NATURE OF THINGS

Beyond Our Senses. Invisible Life. Secrets of Life. Structure of the Atom. Energy Changes in the Atom. General Impressions of Matter: Homogeneity, Intricacy, Activity, Tenuity. Error of Supposing that the Tenuity of the Material Makes the Spiritual Order More Accessible. The Risk of Forgetting "Mind." A Personal Heresy Recommended: Pan-Psychism. The Spiritual Order. Religious Interpretation of the Domain of Things. The "Argument" Summarised.

OWING to the limitations of our senses we are directly aware of only a small fraction of the physical changes that go on in the world. There is much light that we cannot see; there are many sounds that we cannot hear; there are many movements, in which we are implicated, of which our senses give us no direct tidings.

Beyond Our Senses

It is easy to imagine a race of men who would swear that all ordinary bats are dumb, for only a small percentage of mankind can hear the bat's high-pitched voice. This is indeed a parable. With the naked eye we can see two to four thousand stars; with a fine telescope several hundreds of thousands; with a photographic plate as many millions. Without instruments we have only a peep-hole view of

the world. The ant is sensitive to ultra-violet rays, to which we are blind, and a tree may answer back to a passing cloud. Many a beast of the field hears loud signals in the deep silence that we call the 'dead of night.' An earthworm thrills to the tremor of the thrush's footstep, to which we are of course quite dull, and many insects detect differences of pressure in the air, to which we are in ourselves quite callous. We can make an instrument that will register the heat of a candle a mile and a half away, but we ourselves are sensitive only to a very small fraction of the possible temperatures. For electric waves as such we have no sense. What stretches before us is like a mountainous region covered with mist; through the mist there stand out the peaks that we directly know through our senses. The rest is unsensed. But of the immense mist-covered universe—unseen and unsensed—man has come to know much, almost as much as of the peaks, for by means of his instruments he is able to see the invisible.

Yet even with instruments one does not see the gist of the matter; atoms, though real, are invisible. It is possible, however, to observe the path of an atom when it collects water-vapour round itself on its journey through damp air. It must also be remembered that even with the finest instruments very important things, such as the Röntgen rays, may lie before the investigator's eyes for many years and yet remain unnoticed.

Invisible Life

In the realm of organisms, as well as in the domain of things, we have much to do with the invisible. It is not altogether easy to think of a beetle under a hundredth of an inch in length, and this is not the smallest size for an animal with a body. Within that small compass there are organs like those in ourselves—a brain, many muscles, a food-canal, a kind of heart, a respiratory system, and so forth. It is difficult to picture such minute architecture. And how impossible to picture the constitution of the egg-cell within which all that barely visible beetle lay implicit. But a hundredth of an inch is gigantic when we come to minute unicellular or non-cellular organisms that do not build up any body. Many of them can go rushing through a pin-prick opening or the eye of a needle without jostling one another or knocking against the sides. If what are called "filterable viruses," such as those that cause measles, scarlatina, rabies, and the like, are really micro-organisms, simpler than Bacteria and Protozoa, as is highly probable, we have to deal with extraordinary minuteness. For they pass through earthenware filters, which keep back ordinary microbes, and they have not as yet been detected even with the ultra-microscope. Yet these minutiæ are as powerful as they are elusive. It does not take them long to bring the giant to the dust. What po-

tency in a bacillus, less than a five-thousandth of an inch in length, that can duplicate itself every half hour, and that could in five days fill the whole ocean down to the depth of a mile.

Secrets of Life

Bacon said that the task of science was to discover the secret motions of things, and on these of a truth almost all the big things depend. We can see the beating of the heart, but we cannot see what goes on in the muscles. The molecular agitation when a message travels along a nerve; the whirlpool within the neurons, or nerve-cells, of the brain; the invaluable hormones that the blood distributes so that the body works harmoniously—all are in the world of the invisible. Even the microscope does not reveal them.

With the naked eye, we can just see a frog's egg dividing into a ball of cells. It is a tenth of an inch in diameter. With the help of a microscope we can watch the intricate manœuvres that are associated with cell-division. With a still better microscope we can see that the rodlets, or chromosomes, within the nucleus of the cell are split longitudinally up the middle, so that each daughter-cell gets a precise half of each rodlet. With a still finer microscope we can perhaps see that each rodlet, or chromosome, consists of a row of microsomes like beads on a string. Beyond that we cannot go, and yet we have not

come to the units that are fundamental—the "factors" which carry the hereditary characters. In some cases we know a little about the behaviour of these very important and extremely minute bodies; in some cases we can even make a shrewd guess at their size. But see them we cannot, and we thus get another illustration of the limitedness of the familiar saying, "seeing is believing."

Structure of the Atom

If we are to form even an outline picture of the nature of things, we must take account of some of the recent investigations on the constitution of matter. This is the deepest plunge that man has yet taken into the physically invisible world. We pound a piece of stone into sand, we bray it in a mortar into dust—dust so fine that our breath wafts it away; yet if we look at these particles under the microscope we find that they are still coarse-grained and huge. But suppose we could go on doing something like more pounding, we come, in imagination at least, to the smallest particles of a substance that can exist in a free state—the invisible molecules. Some of these molecules are large and have been measured. The mass of the hydrogen molecule is known to-day with comparatively greater accuracy than, say, the value for the mass of the earth (Haas, *The New Physics*, 1923, p. 29). It is estimated that a quadrillion (*i. e.*, a billion billions) molecules of hydrogen

would only have a mass of three grams—about one one-hundred-and-fiftieth of a pound. (A gram is about fifteen and one-half Troy grains, and a grain is one seven-thousandth of a pound avoirdupois.) One of the recent triumphs has been the approximate measurement of the *length* of some very long molecules of fatty acids. All this precision of measurement shows how little it matters whether we see a thing or not.

It is evident, however, that we cannot stop at the molecule, for many molecules are not simple but compound. Thus the molecule of water consists of hydrogen and oxygen—in the proportion of two of hydrogen to one of oxygen. A molecule of water, we say, is H_2O, two atoms of hydrogen to one of oxygen, and this is generally accepted as sufficiently accurate. Our point is simply that a molecule is often compound and built up of atoms, and an atom may be defined as the smallest particle of a chemical element that can enter into or be expelled from chemical combination. But while it was part of the old idea of an atom that it was an indivisible particle (the word means 'what cannot be cut'), it is characteristic of the modern view that the atom may have a complicated structure. To keep ideas clear, it may be mentioned that the smallest amount of an element that can take part in a chemical reaction may also be the smallest amount that can exist in a free state. In other words, atom and molecule may sometimes be

synonymous. Thus, the molecule of mercury is supposed to consist of one atom; whereas the molecule of oxygen is supposed to consist of two atoms. But as the result of investigations centred in the phenomena of radio-activity, it became plain that the atom has likewise a structure and is very far from being indivisible.

The simplest atom is that of hydrogen, which consists of a hydrogen nucleus, bearing positive electricity, round which a single electron, bearing a charge of negative electricity, revolves at a relatively great distance. It may be said at once that we do not know what electricity is; it means a way of behaving. Nor do we know the difference between positive and negative electricity, save that each attracts its opposite and repels its own kind. Every one knows how the rubbed sealing-wax or piece of amber attracts a shred of paper. So the positively charged nucleus of the hydrogen atom attracts the negatively charged electron. All electrons have the same amount of negative electricity, the smallest amount that can exist.

It is easy to picture the outline structure of the hydrogen atom—a nucleus of hydrogen and a revolving electron. But this is far too simple to be typical. Thus, helium has two electrons and lithium three, and so on till we come to the most complex atom known, namely uranium—the ninety-second in the table of chemical elements, which has, nor-

mally, ninety-two electrons revolving round the centre. It may be useful to think of a sun with ninety-two planets.

But the increase in complexity is greater than we have yet indicated. For the atom of helium has twice as much positive electricity in its nucleus as there is in the nucleus of hydrogen. Oxygen, which is eighth on the list of elements, has eight times as much as the hydrogen nucleus, and uranium ninety-two times as much.

Moreover when we compare one atom with another, we must think not only of an increase in the number of revolving planets, and of an increase in the positive electric charge of the centre, which we may liken to the sun; there is also an increase in the complexity of this centre, or sun. Thus the centre of the uranium atom probably consists of two hundred and thirty-eight hydrogen nuclei, or protons, and, outside these, one hundred and forty-six inner electrons.

When an atom has many electrons, it is believed that they revolve in successive rings around the nucleus, approximately in ellipses, like the planets around our sun. But while gravitational force keeps the planets circling, the force in the atom is electricity. Moreover, while the planets attract one another, the electrons repel one another; and again, while the influence of one planet on another is slight compared with the grip the sun has on them

all, the influence of one electron upon another is not slight compared with the attraction between nucleus and electrons. Thus, while it is useful to think of an atom as like a miniature planetary system, we must also recognise that there are many differences between the world of the infinitely great and the world of the infinitely little.

Energy Changes in the Atom

We must not linger too long in a domain where we are personally trespassers, and where most of us soon get out of breath; but we must have our outline picture of this aspect of the unseen universe, and there are a few results of more surpassing interest. What are the functions of the various rings in the system of the atom?

We must think of the planetary system of the atom as thrilling and bursting with energy. (1) When a substance is burned, the energy of the outer whirling electrons is transformed into heat. The same is true of the heat that is generated in other chemical reactions besides combustion. (2) Disturbances in the inner whirling rings of electrons result in the production of X-rays, which have a wavelength ten thousand times less than light rays. (3) When electrons on an outer orbit hop abruptly on to an inner, as a man might pass from one moving circular platform to another, then the liberated energy takes the form of light! (4) When the nu-

cleus of the atom begins to disintegrate, then there are the phenomena of radio-activity—a giving off of Alpha rays, which consist of helium particles moving with about one-tenth of the velocity of light, of Beta rays, which are electrons moving almost as quickly as light, and of Gamma rays, which are of the nature of light-waves, representing the maximum velocity. Associated with the disintegration is the change from one element to another. We must return to this aspect of things in the next chapter, but meanwhile we need the general picture of what Mr. Bertrand Russell calls the 'small fierce world' of the atom.

General Impressions of Matter: Homogeneity, Intricacy, Activity, Tenuity

Perhaps we have said as much as is wise, or necessary for our present purpose, in regard to the nature of things; let us gather together the big results that must be taken account of in a religious cosmology. What are the general impressions that are left after a study of modern inquiries into the constitution of matter?

Perhaps the largest result is a new vision of unity. The world is fundamentally homogeneous. As far as matter goes, everything seems to consist of electrons and of protons, the latter being otherwise called hydrogen nuclei. These electrons and protons are the building-stones of the universe, 'the stuff

out of which worlds have been spun.' One element differs from another in the structure of its atoms, and one atom differs from another in the number and arrangement of its electrons and protons.

A second impression is that of extraordinary intricacy. Instead of picturing minute indivisible hard atoms, like ultra-microscopic grains of sand, variously named carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, iron, silver, gold, radium, uranium; we must think of each atom (except the very simple ones) as like a complex solar system, electrons revolving in circles or ellipses around a central sun; and each central sun has got its complexities of protons. This is indeed like William Blake's "a world in a grain of sand."

A third impression is the entire falseness of the idea of inert matter. Everything is a bustle, but in most cases a very orderly bustle. To take the simplest case, the electron of the hydrogen atom revolves in its tiny orbit round the proton at the rate of about fourteen hundred miles in a second; in a millionth of a second, it goes round its orbit about seven thousand million times (Russell, *A B C of Atoms*, 1923, p. 36).

A fourth impression is that matter has become very tenuous, what one might call delicate. "To the eye or to the touch, ordinary matter appears to be continuous. Science, however, compels us to accept a quite different conception of what we are

pleased to call 'solid' matter; it is, in fact, something much more like the Irishman's definition of a net, 'a number of holes tied together with pieces of string.' Only it would be necessary to imagine the strings cut away until only the knots were left" (Russell, *A B C of Atoms*, 1923, p. 7).

When we see a man wielding a sledge-hammer and coming down with all his might against the wedge that splits the rock, we at once think of the perfectly hard atoms of the ancients. They seem to fit in with every-day experience better than do the planetary systems of modern atomicity. It is of interest, however, to note that investigation has shown that there is a remarkable perfection of hardness in the modern atom. For it seems that the inner rings of electrons form an impenetrable bulwark, so that the heart of the atom is after all as hard as a cannon ball. This fact will not, of course, be mixed up with the familiar process of pressing one atom or molecule nearer another, so that a gas becomes a liquid, or a liquid a solid.

Error of Supposing that the Tenuity of the Material Makes the Spiritual Order More Accessible

Undoubtedly, the modern investigation of matter, though it does not affect things as they seem, has changed our view of things as they are. Matter is less gross, more delicate than we thought. It consists of electrons and protons, as invisible as the air

we breathe. Just as air requires dust particles to make it visible, so we cannot see matter until it becomes either dusty or close-packed. Here, however, we must avoid a mistake sometimes made to-day by well-intentioned people. How tenuous, some say, has the material screen become that separates us from the spiritual order. This is surely away from the line of truth. The spiritual is not a reality that will be made more accessible by any thinning or etherealisation of matter. It is spiritually discerned. Moreover, matter is not so much a screen hiding God as a medium in which the Divine Art finds expression.

> "Trees in their blooming,
> Tides in their flowing,
> Stars in their circling,
> Tremble with song.
>
> God on His throne
> Is eldest of Poets;
> Unto His measures
> Moveth the whole."

Two distinguished physicists, Professors P. G. Tait and Balfour Stewart, wrote many years ago a book entitled *The Unseen Universe*, still worth reading. They argued very strongly from a scientific point of view as to the reality of a spiritual unseen universe which they thought of as completing and continuing and even influencing the visible universe, but, so far as we understand their position, they do

not seem to have thought that the tenuity and invisibility of the stones and mortar of the material universe was in itself any approximation to what they called the Unseen Universe, which was a spiritual kingdom.

It seems to be away from a hopeful direction of truth-seeking to suppose that the etherealisation of matter brings God nearer. Some years ago it was the fashion in physical science to make much of the ether, a hypothetical medium invented because of the difficulty we have in picturing waves without something that undulates. During that period several theological essays were published which sought to show that the ether was a sort of scientific name for God. This seems an unfortunate line of thought, for the ether was and is only a hypothesis, some would say a needless one. That it will not return after a while we should not like to say, but it is not at present of much moment in any cosmographical picture.

The Risk of Forgetting "Mind"

The chemico-physical world concerns itself with electrons and protons and with electro-magnetic waves of varied frequencies which traverse space. There is a deliberate ignoring of "Mind," and this seems justified by the fact that as long as we keep to the so-called inanimate world—the domain of things—there seems no need for "Mind" as a de-

scriptive category. But what is practically permissible in the domain of matter and motion apart from life is impossible in the realm of organisms. For there, increasingly, mind seems to 'count.' Not less important than the physical invisibility of atoms and waves that we have spoken of is the invisibility of the "imponderables" which have in Animate Nature a progressive manifestation as agencies that get things done. We mean, of course, thoughts and feelings and the bent bow of purpose, which, though thirled in our experience to brain and body, nevertheless belong to a different dimension from these.

The triumphant analytic successes of chemistry and physics are, of course, themselves direct evidences of the supremacy of mind; but there is a risk of forgetting this truism when we are dealing with sciences that deliberately leave "Mind" out. Just because "Mind" is negligible as a factor in describing the nature and activity of the non-living world, there is apt to arise a disinclination to give it its full value in the higher sciences.

A Personal Heresy Recommended: Pan-Psychism

This brings us to suggest a glaring personal heresy, *that there is nothing inanimate.* We do not mean that the mountain stream is self-conscious as it sings or that the precious stone glows with emotion; we mean to suggest that there may be throughout all the world a something interfused which is not discerned

by those scientific methods that catch matter and energy. It slips through the meshes of their net. We mean that there may be in the crystal and the waterfall the analogue of what we call mind in ourselves. Perhaps all the objects of sense-experience have a metakinetic as well as a kinetic side, a mental as well as a material, a psychical as well as a physical. Perhaps everything is like a dome, with a concave as well as a convex side. Perhaps everything is like a shield, with its side of silver and its side of gold.

It is easy to burlesque this idea. It is easy to ask, Do you mean that the chucky-stone has a soul? Are you projecting the man not only into the beast but into the very dust? But let us reason together.

Matter is, after all, an abstracted aspect of reality which we separate apart by rigidly following certain methods of scientific analysis. The chemist gives an account of a pearl, but he says nothing of its beauty. The physiologist can tell us much about the nightingale's song; but he deliberately leaves out the bird's emotion. Mind is another abstracted aspect of reality which we separate apart by other methods —the surest reality in the world to us being our own self-conscious purpose which we cannot measure or weigh. Yet no one would say that it was quite independent of the body which it sometimes transcends.

Let us remember also how long is the inclined plane on which mind finds expression. Among very simple creatures it seems like an intermittent light;

it slumbers deeply in vegetative animals like corals, whose beautiful forms and colours are their dream-smiles; it finds richer expression in ant and bee and much richer in bird and beast; in man it sometimes shines in a very perfect day.

Let us consider also how beautifully gradual is the dawn of mind in the individual becoming. "In thy book," the Psalmist wrote, "all my members were written, which in continuance were fashioned when as yet there was none of them." How well he might have said the same of the mind. We cannot say: "Lo here or Lo there"; the mind of the child is like the opening of a blossom.

It is too soon, perhaps, to press another argument, to which we must return. We refer to the origin of organisms upon the earth. There is much to be said in favour of the admittedly difficult view that living organisms emerged from the dust of the earth. If so, and if the world's process is continuous, then there must be in the dust the promise and potency of life. And where life is, mind may be. If the dust of the earth came from the primitive nebula, then in the nebula also there must have been more than met the eye. We shall not press this argument; but when we hear one say too loudly: "All came from the protons and electrons of the primeval fire-mist," we answer firmly: "No, not from matter and energy only, but from matter and energy and *mind*." "In the beginning was Mind," and that same Mind is the light of

men. We adhere tenaciously to the Aristotelian idea that there can be nothing in the end which was not also in kind in the beginning. And by no "joukery-pawkery," as Scots folk say, can "Mind" be got out of "Matter." If it seems to emerge, it is because it was there all the time.

A Spiritual Order

But it is not to this *immanent psychism* that we mean to refer when we speak religiously of the Unseen Universe. The religious concept refers to a Spiritual Order, which can only be spiritually discerned. It is the glimmering of an idea that behind all is the will of God. It is the idea of a Creation which was not an event over and done with unthinkable millions of years ago, but remains as an enduring Divine thought. But God's relation to His world must remain entirely beyond man's comprehension. The Divine Imagining is beyond man's imagination.

One way of thinking of it we may safely exclude. We must not think of something Divine that underpins the material universe and its psychical correlate. It seems inconceivable that the world should need any underpinning, else were there great imperfection in the creative institution of the Order of Nature. It is more conceivable that the "irreducibles," such as electrons and mind, which were the work of His hands, were quite able for the work that He gave them to do.

Religious Interpretation of the Domain of Things

What has this inquiry to do with the relations between religion and science? The answer is that the scientific picture of things as they are becomes more and more congruent with our conception of God, and may even enhance it. The modern scientific picture has given the material universe a new unity. We have found what are at present the physical irreducibles—electrons and protons and waves in Space, and the other irreducible is Mind. For the time being, these are the common denominators. The world is one, and our vision of God is a vision of the One. It is an impressive fact that one system of formulation suffices in the chemico-physical world from the smallest particles to the stellar universes. This unification is congruent with the concept of God.

The world is one; fundamentally homogeneous; a universe, not a multiverse; it is in a way curiously simple; it is teeming with power—there are modern conclusions which seem to fit in well with our thought of God, who is spiritually discerned.

But there is also the big fact of law, which means not only a certain degree of intelligibility but an inherent orderliness; everywhere uniformities of sequence, a cosmos, not a phantasmagoria. Perhaps the only apparent exceptions are to be found in the discontinuity which seems to occur within the atom

when X-rays are given off from the inner ring of electrons or when there is a spontaneous disintegration within the nucleus of the atom. But of the world within the atom we have as yet only glimpses.

When we speak of the intelligibility of the material universe we mean that there are uniformities which we can approximately formulate. But it is too soon to think that we are in actual touch with the real rules of the game. Indeed one of the modern experts has expressed his suspicion that only one real Law of Nature has as yet been discovered. That the approximate Laws of Nature are more than man-made formulations is evidenced by the fact that we can use them as a basis for prediction. Perhaps, however, in such phenomena as the discontinuous hops of electrons that seem to occur in atoms, we have a warning that what actually happens may not be in accordance with our ideas of rationality. Even in our science we are apt to be anthropomorphic. Some one has said that the more rational a Law of Nature appears to be, the less likely it is to be near an expression of what actually takes place. It need hardly be said that there is another use of the phrase 'the rationality of Nature,' which refers to the meaning or purpose which may be behind it all. This raises an inquiry quite beyond science.

We have sympathy with those who say: Your protons and their swinging electrons, like multiple Saturn's Rings, are certainly very interesting, but

they leave us cold. We turn from your God of electrons to the God of our youth, who made the morning stars sing together and the little hills clap their hands, who makes the clouds His chariot and yet moulds each drop of dew. But there is no reason why both views may not be held. For the God of the electrons and protons is the God who made these irreducibles make the mystery of the mountains and the sea and sky eternally new.

Moreover, there seems a note of grandeur in the modern revelation of the simplicity of materials. We admire the artist who says: Give me but three things and I shall make you a crown for a king. It appears to us that the manifold glory of the world is not lessened in our every-day experience by the discovery of the small number of irreducibles. Rather does the whole become more wonderful when we realise clearly that these inexhaustible riches arise from fresh permutations and combinations of a few things. Some new potentiality of the irreducibles is ever coming to light. The world discloses itself to us like the heart of one we love who is new to us every day. The evolutionary emergence of finer and finer aspects of reality in the course of the long history increases our appreciation of the potential richness of the irreducibles—Matter, Energy, and Mind; or perhaps, Electricity and Mind.

Simple as the physical world may be from the analytic point of view, it remains as grand as ever.

The starry firmament on high is not less glorious, because it also is built up of electrons and protons, and emerged as starry clusters from vast incandescent nebulæ. We are citizens of no mean city. We are short-lived creatures on a small planet, belonging to a solar system which occupies only a small corner in space and is ever leaving that corner behind without getting appreciably nearer that unknown goal which is called "the apex of the sun's way." Yet we have some understanding of our system, and of other systems, and of vast galaxies of stars; we analyse stars whose light left them centuries ago; we see stars being born and others growing mysteriously dim. We are citizens of no mean city. Its splendour is not lessened by the fact that we have come to know something about the bricks and mortar out of which the whole city is built. "The undevout astronomer is mad."

Another fact about the physical universe which must find its place in the picture which religion will illumine, is the fact of beauty. The essence of beauty remains a secret, but it is not a subjective illusion. It is a quality in things which arouses in us a quite characteristic thrill—the æsthetic emotion. We plead for regarding it as an emergence of an aspect of reality, which may be cognate to mind. In living creatures there is a kind of beauty that expresses a harmonious constitution, but we all know another kind that shines out from mind and character. So

we venture to suggest that the beauty of crystals, of precious stones, of minerals, of hills and valleys, may be the expression of the sub-vital analogue of mind. There is possibly some fallacy here, but it is not so great a fallacy as declaring the beauty of the physical universe to be an echo of some association in our minds.

The 'Argument' Summarised

The general 'argument' of this study, if it can be called an argument, is this:

(1) The investigations of science lead us to recognise a growing intelligibility in the world. There is an immanent order; there is unity, simplicity, continuity, and a kind of progressiveness. There science, as such, stops.

(2) But if, as thinking men and women, we pass beyond science and inquire into the institution of the Order of Nature, into the original endowment of its irreducibles, and into the development of the homogeneous seeds till they grew into many kinds of flowering plants with diverse blossoms—we may be led to something like a Deistic position.

(3) If we press still farther beyond science, and think particularly of man, in whom the Spirit of Nature becomes articulate; if we venture to inquire into the meaning and purpose of the whole cosmic process; if we try to see the whole in the light of Man and his kingdom, we are borne towards a Theistic

position—God and His Kingdom. This becomes easier in the light of Christianity.

Subtleties apart, three results stand out. Even if we leave life unconsidered, we live in a very wonderful world, surrounded with things angels might desire to look into. Part of the wonder is in the world's unity amid diversity, its simplicity behind manifoldness. As Theodore Parker said, it is a handful of dust which God enchants. Even greater perhaps is the wonder that man with his limited senses has come to know it so well—so well that he can bend the Titan to his purposes. Still greater perhaps is the wonder that the big discoveries on which all the great controls and inventions depend are in the world of the invisible. The formulations of the motions of invisible particles furnish levers with which we can move mountains. We believe in them because they work so well, because they afford a basis for predictions that have been verified. They make foresight possible and have given a large control of Nature into man's hands. But within the physico-chemical invisible universe there is, we have reason to believe, an interfusion of mind, and this certainly finds articulate expression in the higher reaches of life. And behind the physical and the bio-psychical, there is, we have reason to believe, an unseen universe of a spiritual order. This belief works well. Perhaps we are too much given to the adage: "Seeing is believing"—a very good scientific motto within its limits.

Perhaps, with due precautions, we might oftener take a new motto: "Believing is seeing."

SUMMARY

(1) Of a great part of even the near world we have no direct knowledge through our senses. If the spectrum of visible light be represented by an octave, there are many invisible octaves in the lower infra-red end and many invisible octaves in the upper ultra-violet end. By direct vision we get only a peep-hole view of the universe. Even to the most ingenious instruments much remains invisible.

(2) Many complicated animals are on the border-line of naked-eye visibility; thousands of different kinds are microscopic; many of the deadly "filterable viruses" (if these can be ranked as organisms) have never been seen at all.

(3) All the important vital processes, whose symptoms are macroscopic, occur in the world of the invisible. We analyse a living creature into lower and lower terms: organs, tissues, cells, nucleus, chromosomes, microsomes; and then we pass beyond the visible to the invisible "factors" which carry the hereditary characters.

(4) The deepest plunge into the physically unseen is the modern study of the constitution of matter. We pass beyond the smallest visible particles of any substance to the invisible molecules—the smallest portions of a substance that can retain integrity in a free state. But many molecules are compound and consist of atoms—the smallest particles of a chemical element that can enter into or be expelled from chemical combination. But the atom is no longer an indivisible entity. The simplest atom is that of hydrogen, which consists of a hydrogen nucleus, or proton, bearing positive electricity, round which there revolves a single electron bearing a charge of negative electricity. The most complex known atom, that of uranium,

consists of ninety-two electrons revolving in orbits round the centre, while the centre is again a microcosm, consisting of two hundred and thirty-eight hydrogen nuclei and one hundred and forty-six electrons. According to some authorities, we are justified in saying that a hydrogen nucleus, or proton, is a positive charge of electricity. In any case, all atoms consist of electrons and protons, and the different elements form a system, the members of which, ninety-two less four gaps, differ from one another in the number and disposition of the fundamental building stones.

(5) The planetary system of the atom is bursting with energy, which we know in combustion, in the production of X-rays, and in radio-activity. When a substance is burnt the energy is transformed from the whirling outer electrons. When an electron suddenly hops from an outer ring to an inner ring, light is produced; and the X-rays are due to disturbances in the inner electrons. But there is most energy in the nucleus of the atom; it is a storehouse that we get a glimpse of in radio-activity. In this remarkable phenomenon there is an explosive disintegration of the atom, and there is, notably, an emigration of Alpha-rays, or helium particles, and a change in the chemical nature of the element.

(6) Modern chemistry has revealed, from one point of view, extraordinary complexity—most atoms like whirling solar systems—Blake's "world in a grain of sand." From another point of view, it has made the world one, for all matter consists of diverse collocations of electrons and protons. The idea of inert matter must be entirely given up; there is a bustle in the very dust. It is plain that matter has become very tenuous or delicate; and yet there is a remarkable modern justification of the old concept of the "hard" atom.

(7) The general result of the modern inquiry into the constitution of matter is to make the material screen more tenuous than it seemed to our forefathers, and some have

drawn the conclusion that this has made the spiritual order or the spiritual aspect of reality more accessible. It is probable, however, that this idea is a confusion of thought. The spiritual is spiritually discerned.

(8) The chemico-physical world, with its constellations of electrons and with its various sets of electro-magnetic waves traversing space, is a world in which "Mind" is deliberately ignored. When we keep to the chemico-physical world in itself and apart from life there does not seem to be any need for 'mind' as a descriptive category. But this is not permissible in the realm of organisms. For there, increasingly, mind seems to count. Thus below the invisibility of the "ponderables," there is a deeper invisibility of the imponderables—thoughts and feelings and the bent bow of purpose.

(9) It seems not unreasonable to revive the old heresy, that there is nothing strictly *inanimate*. It may be that all the objects of our experience have two aspects, metakinetic as well as kinetic, mental as well as material, psychical as well as physical. This is the heresy of pan-psychism. (*a*) It must be noted that "matter" and "mind" are both abstract aspects of reality. Matter is a fish caught in a net whose meshes are specially adjusted to let mind slip through. (*b*) There is a long inclined plane in the expression of mind in the realm of organisms. (*c*) There is another inclined plane of expression in individual development. How gradually mind emerges from unrecognisable implicitness. (*d*) Moreover, if living organisms evolved from the non-living, then there must have been in the non-living the promise and potency of mind as well as of life. The naïve assertion that all came from electrons and protons and electro-magnetic waves in the primitive nebula, must be supplemented by the older doctrine: "In the beginning was Mind." For there can be nothing in the end which was not also present in kind in the beginning.

(10) But immanent psychism does not mean more than

that there is throughout all creation a metakinetic aspect, the analogue of the mind of man and of all the more effective animals. Even this view does not lead us to *the* Unseen Universe, which is a spiritual order, and must be spiritually discerned. It means that behind all there is the Will of God, a Divine Thought, perhaps a Divine Imagining.

The relation of God to His World is plainly far beyond man's apprehension, but there are some lines of thought that seem to be in an unpromising direction. Thus, just as it seems on the wrong road to think of God as a synthesis of all the powers in the world, so it is probably on the wrong road to think of Divine Energy underpinning the electrons and protons. These are the works of His hands, and they were not left half-finished.

(11) The important conclusion is reached that the scientific picture of things as they are becomes more and more congruent with our conception of God, and may even enhance it. The world is one; fundamentally homogeneous; a universe, not a multiverse; it is in a way curiously simple; it is teeming with power; it is progressively intelligible, even though our discovery of the real laws of Nature is still young; it is a cosmos, not a phantasmagoria. The analytic view leaves one colder than does the naïve outlook of our forefathers, but there is an artistic triumph in the fashioning of such manifold and progressive grandeur out of a few irreducibles. The analysis of matter into electrons and protons leaves the beauty and grandeur and expressiveness of our world unaffected. The simplicity of the building stones increases our appreciation of the architecture; the economy of materials increases our appreciation of the artistry; the progressive preparation that one stage makes for another is strongly suggestive of purpose.

(12) The general 'argument,' though it is not an argument, is this: (*a*) The investigations of science lead us to recognise an immanent order in the world. There is unity, simplicity, continuity, and a kind of progressive-

ness. There science, as such, stops. (*b*) But if we pass beyond science, and inquire into the institution of the Order of Nature and the original endowment of its irreducibles, and into the development of the homogeneous seeds till they grow into many kinds of flowering plants with diverse blossoms—we may be led to a Deistic position. (*c*) If we press still further beyond science, and think particularly of man, in whose spirit the Spirit of Nature becomes articulate; if we venture to inquire into the meaning and purpose of the whole cosmic process, we are borne towards a Theistic position.

Many scientific theories are like "wisdom justified of her children." They work well; they make foresight possible; they give man control. All the deepest of them are concerned with the materially invisible, though the characteristic scientific motto is: "Seeing is Believing." Perhaps, however, we should give more generous hospitality to religious interpretations which are concerned with the spiritually invisible. Here also wisdom is justified of her children, and the characteristic motto is: "Believing is Seeing."

CHAPTER III

THE POWERS OF THE WORLD

The Outlook of Primitive Man. The Nature Psalmists. The Modern Change of Temper. The Transformation of Energy. A Short-Cut to Deity. The Conservation of Energy. The Origin of Energies. Atomic Energies. The Quantum Theory. Relativity. The Outcome of Our Survey.

The Outlook of Primitive Man

PRIMITIVE Man must have been impressed by what we call the Forces of Nature, which gripped him as a giant lifts a child. What was he in the thunderstorm, when even the firmament trembled and the lightning brought the great tree to the ground, riven and charred? What was he in the earthquake, when the solid ground heaved and cracked, and the roof of the cave fell in? What was he when the volcano blotted out the sun and belched out lava? What was he when a great and strong wind rent the mountains and brake the rocks in pieces? It is impossible for us to imagine what primitive man thought of the fierce floods, which before them all things drown; or of the raging streams with their proud swelling waves; or of the cruel sea; or of the mysterious pestilence that walketh in darkness, and the destruction that wasteth at noonday. We cannot think ourselves back into the dull outlook when none of these powers was understood, when

the idea of mastery had not dawned. What could man do but credit these powers with *intentions* and people the earth with dæmons? These were the days before science, when primitive religious activities were the tendrils of incipient personalities strained by fear, helplessness, the instinct of self-preservation, and the feeling of mystery. These were the days of magic on the one hand and of appeasing sacrifices on the other. It is probable that long before any theory of animism, there was the simple childish conviction that outside powers and objects did things as man himself did things. Some children have this conviction to-day, and the most modern golfer addresses his errant ball as if it were a malignant spirit.

The Nature Psalmists

Very different from the crepuscular outlook of early man was that expressed in the finest of the Nature Psalms. Jehovah is in His heaven now, and man has worshipped Him there. The wildness has gone out of Nature; the Lord reigneth. There are terrible forces, no doubt; but man has entered into his spiritual kingdom, and even when he is sore afraid he is content. "Though He slay me, yet will I trust Him." The world is God's handiwork and under His control; the religious mind rejoices in Nature's revelation, in the richness and beauty of the earth.

We do well to linger over the relation of the Hebrew seers to Nature, for there has been nothing like it since. There is such naïve enjoyment of the world, a sheer delight in it as a revelation of the glory of God—not to be taken in any impressionist way, but to be considered in detail. Take for instance the appreciation of the hippopotamus!

"See Great Behemoth with his ruddy hide
In the shade of the lotuses
Encircled by water-willows.
From the wild rushing torrent he flees not;
He is calm in the swell of a Jordan.
Behold now the strength in his loins,
And the force in the muscles of his belly.
His bones are as pipes of brass,
His limbs are like bars of iron.
He is the chief of the ways of God."

Or take one of the religious meteorological pictures:

"God spreadeth His vapour around Him;
He covers the tops of the mountains.
Therewith He sustaineth the nations,
And food in abundance He giveth.

"He wrappeth His hands in the lightning,
And biddeth it fly to its mark,
His thunder announces His coming;
His anger is kindled at wrong.

"God letteth us see His wonders;
Great things beyond knowledge He doeth.
For He saith to the snow, 'Fall earthwards';
Likewise to His strong rushing rain."

. . . .

"By the breath of God ice is given,
The broad waters lie in constraint.
Yea, He ladeth the thick cloud with hail,
And the cloud doth scatter His lightning.
This way and that way it darteth,
Turning about by His guidance.
Doing whate'er He commands it
Over the face of His world,
Whether for curse and correction
Or in mercy He sendeth it forth."

. . . .

Sometimes there is an expression of cosmic awe, but never in any platitudinarian way; and it is mingled with a confidence that this terrible omnipotence will not allow His people to suffer confusion. One reads this clearly in Psalm 78.

"Thou art the God that doest wonders;
The waters saw thee, O God, the waters saw thee;
They were afraid; the depths also were troubled.
The clouds poured out water; the skies sent out a sound;
Thine arrows also went abroad.
The voice of Thy thunder was in the heavens;
The lightnings lightened the world;
The earth trembled and shook.

"Thy way is in the sea, and Thy path in the great waters;
And Thy footsteps are not known.
Thou leddest Thy people like a flock by the hand of Moses and Aaron."

No doubt, there were varying degrees of insight, but one is probably misinterpreting if one thinks that the Hebrew seer was very anthropomorphic in his contemplation of the Powers of the World. He had

the Vision of God and in the light of this he looked on Nature with great appreciation—sometimes full of awe and reverence, sometimes full of joy and delight.

We do not stand alone in suggesting that the Nature psalmist did *not* think that the thunder was God's voice. He did not know what it was; he was in an exalted state of feeling; Nature spoke to him and the echo in his heart was God. He had passed beyond being afraid of noises: God's in His heaven, all's right with the world.

> "The heavens declare the glory of God,
> The earth showeth forth His handiwork.
> Day unto day welleth forth speech,
> Night unto night breatheth out knowledge.
> There is no speech, and there are no words,
> But their voice reverberates through all the earth."

The psalmist had gone *a long way* on the far side of the rather prosaic idea that the thunder was God's voice!

As the view we hold seems to us to be of importance, let us quote a few corroborative sentences from an essay on "God in Nature and History" by a shrewd Scotch student of the Old Testament (*A Scotch Student, Memorials of Peter Thomson,* By George Steven, 1881, Edinburgh). In reference to the 29th Psalm, where the poet speaks of the thunder as God's voice, Peter Thomson writes:

"We venture to lay down the thesis that the poet

did not mean thereby to give us any information about the physical cause of the thunder, that the state of mind from which the apprehension of God resulted was not that of mere scientific curiosity about the cause of the observed phenomena. He does not mean to say that the thunder is caused by God speaking, just as the articulate sounds we call words are produced by men speaking. Had the phrase, the voice of Jehovah, been meant as an explanation of the cause of the thunder, it would have been a degradation of God to the level of man, by bringing Him within the sphere of the sensible, by co-ordinating Him with the creatures and thus destroying His infinite and transcendent character. . . . Mere curiosity about causes can never grow into religious emotion. . . . The psalmist is not in the passionless and prosaic state of seeking an explanation of the thunder; he is expressing religious experience of the most exalted kind. It is not his reason or understanding that is active, but, as the whole hymn shows, his spirit, his religious nature. . . . The thunder is Jehovah's voice to him, because in the thunder Jehovah speaks to him, because the effect of the thunder is an awakening of his religious nature, a setting of him face to face with God, an excitation of religious emotion. Each peal that echoes and re-echoes from heaven to earth stirs the poet's inmost religious nature, that shrine of his heart where Jehovah alone dwells. The deep thrill

that passes through his soul as he stands watching the storm could be produced by Jehovah alone. It is an emotion essentially religious, not æsthetic, and not scientific; and this he can express in no other way than by saying that Jehovah caused it."

It comes to this, the psalmist had the vision of God in his heart's shrine, and the intense emotion excited by the storm passes beyond astonishment, beyond fear, into a religious sublimation in which it finds relief. When what Emerson calls the slender rill of human sense is altogether overfilled, the emotion often becomes religious. This overfilling of the rill of human sense is one of the chief contributions that science makes to religion, and the contribution has never had such volume as it has to-day. But has religion answered back? There was then among the Hebrews what Emerson calls "an original relation with Nature." It had three elements in it—a recognition of Nature as a revelation of its Creator, a providential view that all is divinely controlled, and a genuine delight in the here and now. Why should not we also have an original relation with Nature?

The Modern Change of Temper

What are the changes that have forced modern man away from the psalmist's religious interpretation of Nature with its characteristic directness? The chief change has been the scientific disclosure

of the Order of Nature. Everything happens according to rule. Given certain conditions, and the thunderstorm, the flood, the tornado, the earthquake *must be*. Given certain meteorological conditions and the snow falls earthwards like wool; in other conditions dew forms on the tender herb. All is according to law. Yet these Laws of Nature have no authority which things obey; they are but formulations of the orderly routine of our experience. The Laws of Nature are not the Thoughts of God, as was often said, except in the sense that the institution of the Order of Nature may be regarded as divine; and in the long run, as the evolutionist or genetic view made clear, we must push the Order of Nature back and back till we reach the irreducibles of a Nebula—which, to our thinking, must be regarded as including the metakinetic analogue of what afterwards emerged as 'Mind.' No doubt the Laws of Nature are adumbrations of a fundamental orderliness necessitated by the nature of things, and must approximately grip reality; otherwise we could not make predictions on the strength of them; but the history of science shows that even useful and reliable laws have not always stood the test of time. In short, the eirenical saying that the Laws of Nature are the Thoughts of God is speaking two languages in one sentence. But the modern change of temper has also been brought about by the acceptance of the idea of a natural evolution—inorganic

as well as organic. The Hebrew seer had no idea of an autonomous and evolving system, sufficient unto itself, requiring no underpinning, no subsidiary or secondary guiding, no immediately supporting hand. His idea was at the very opposite pole. Therefore, when he asked, as we still ask, whence and whither and to what purpose all this, he could give a religious interpretation much more direct than is available for us. But should it not be our endeavour to recapture the religious view of Nature which is a lightening of the eyes? Towards this end we take a survey of some of the outstanding facts known in regard to the powers or energies of the world.

The Transformation of Energy

Energy is the power of doing work, and the two most important facts about it are its Transformability and its Conservation. Energy is sometimes in *potential* form, as may be illustrated by the reservoir of water on the hillside which may be made to turn the wheels of distant mills; or by the barrel of gunpowder, which may do much mischief if it explodes; or by the loaf of bread, which may be re-expressed in useful work when it is digested. More familiar are the diverse forms of *actual* energy, such as that of bodies in movement, like the stone slung from a sling; or the gravitational attraction that determines the movements of the planets in their orbits; or that rapid movement of particles which we

call heat; or the various kinds of electro-magnetic waves which we know as electricity, magnetism, and light. The fundamental exhibition of energy is to be found in the intra-atomic movements of electrons.

The first great fact in regard to the energies of Nature is their transformability. The Greeks imagined an elusive being whom they called Proteus, who was always passing from one guise to another, and that is characteristic of energy. A certain amount of mechanical energy, such as that of a waterfall, is changed into electricity, which can be used to do mechanical work. It is very interesting to see Faraday reaching forward: "I have long held an opinion," he says, "almost amounting to conviction, in common, I believe, with many other lovers of natural knowledge, that the various forms under which the forces of Nature are made manifest have one common origin; in other words, are so directly related and mutually dependent, that they are convertible, as it were, to one another, and possess equivalents of power in their action." He himself was able to give proof of this, for just as Oersted and Ampère had produced magnetic effects from an electric current, so Faraday proved that magnetism could be converted into electricity. He was one of the unifying geniuses and had a prophetic assurance of the electro-magnetic nature of light, which Clerk Maxwell demonstrated. We need not pursue the subject: the different forms of energy are transformable into

one another. The unification of light, electricity, and magnetism has been followed in recent years by other unifications. Few of us are able to follow the process of Einstein's reasoning, but we should have an apprehension of one of the great results of his work, that the energies familiar in gravitation and the motion of material objects have been linked to the radiant energies of Electricity, Magnetism, and Light. The force that keeps the earth whirling round the sun is gravity; the force that keeps electrons rushing round the nucleus of an atom is electricity. It was impossible until lately to bring these into line; but in some measure this has now been done. In the opinion of many competent judges, Einstein has shown that gravitation and the movements of the tornado and the explosive expansion of the heated water come into line with the radiant energies of electricity, magnetism, and light. The two sets of energies are at last seen to be parts of a greater whole. The energies of Nature are all connected—if we admit certain tentative bridges across yawning gullies—and the powers in the world are one.

A Short-Cut to Deity

The scientific conclusion that all the physical energies—such as heat, light, electricity, gravitation—are fundamentally bound together in unity and transformability seems to have suggested to some

minds a short-cut to deity. Thus, a distinguished man of science has been known to declare that God was to him the sum total of the energies of the universe. But we cannot believe that the Truth lies along this line of thought, except in so far as every unification brings us nearer The One. The sum of all the physical energies in the universe is still only physical energy—a measurable power, not an Infinite God. Another distinguished investigator has said that when we add to all the powers on earth the powers of all the stellar universe, and when we add to these all the powers of life, and when we add to these all the powers expressed in our urges and instincts, our values and our ideals, we come near a concept that sums up the universe, and that is God. We venture still to doubt whether this is a clear line of thought. We know in sample all the items of the wonderful addition sum just suggested. We know the gravitational energy of the falling apple, and it does not change its character when Newton tells us that the same power sways the moon and the planets and the most distant star. It is a magnificent unification, but it is not divine. We know the light of the candle, the sunshine, the cold light of the firefly, the electric light, and so on; we know that they are wave-motions of varied lengths; that they belong to the electro-magnetic series; we link the rushlight to the gleam that set out from a distant star centuries ago. It is a magnificent generalisation, but

it is not 'divine.' Nor can we take refuge in the underpinning idea, that what gives the gravitation and the electricity its power is God. This is subsidising Nature with spiritual grants. Why, to speak as men, should God make things imperfect, inadequate to carry out His purposes? It seems shrewder to get back to the idea of Creation—the world is the work of God's hands. In His Infinite Wisdom he has ordained all things "by measure and order and weight." According to the latest reports, there is a finite Universe, but there cannot be a finite God. We hope not to be thought of as doubting that God is the constitutive principle of the Universe, "the source and home of the whole order of the world," but we see no particular value in the idea of a God who is the sum total of the energies of the world. The relation of God to the world must be far beyond our thoughts—we cannot even think clearly of the interdependence of our 'Mind' and our 'Body.' But it must be a spiritual relation.

The Conservation of Energy

The second big fact is the conservation of energy. As Clerk Maxwell said: "The total energy of any material system is a quantity which can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible." There is no creation or destruction of power; nothing

is ever lost. In any closed system in which a series of operations takes place, the amount of energy at the end must be the same as at the beginning, if the energy of the work done is taken into account. What happens may be compared to what occurs in a change-office outside the gates of any big Exhibition or the like; there are a great many little transactions in the course of the day, but the cash at closing time should be the same as it was when the office opened. But there is this marked difference, that whereas the change-office began with much silver and ended with many notes, a more condensed and portable form of energy, the tendency in Nature is towards dissipation or degradation of energy. Every transformation involves a sinking of part of the energy into less available form, ultimately the diffused heat of particles in motion. There are antagonistic processes, especially on the part of living creatures which protest against the running down of the clock, but, in the long run, degradation wins.

So far as our experience goes, then, energy, or the power of doing work, cannot be created; it can only be changed from guise to guise. Similarly, though it may pass into unavailable form, we cannot destroy it. Energy cannot be lost, and thus one of the modern leaders, Professor Frederick Soddy, speaks of it as "eternal." We are not sure, however, that "eternal" is a scientific concept at all. Perhaps we should observe the caution shown by Professors P.

G. Tait and Balfour Stewart when speaking of the Conservation of Matter in their *Unseen Universe:* "We are not led to assert the eternity of stuff or matter, for that would be an unauthorised application to the invisible universe of the experimental law of the conservation of matter, which belongs entirely to the present system of things."

There is a risk of unwarrantably generalising the law of the Conservation of Energy and using it in connections where it is not relevant. Thus it has been used to throw suspicion on the reality of mind, since the energy-accounts balance without allowing anything for "the power of thought." The law applies to physical energies, and it is an experimental induction. If we can estimate with accuracy the sum of potential and kinetic energy in a closed system at the beginning of a series of operations, and if we can do the same when the transformations have been effected, the sums should be precisely the same. But it is difficult to be sure that we are exhausting all the energies in a given collocation. Professor Ernest W. Hobson warns us of this in his great work, *The Domain of Natural Science* (1923): "The fact that we have no assurance that all the possible forms of energy which may occur in physical phenomena are known to us, makes it impossible to conceive that the principle (of the Conservation of Energy) should admit of anything like complete empirical verification." But the Theory of Relativity includes the

assertion that to add to the energy of a body is to add to its mass at the same time; if this theory be accepted, the result emerges that only a united Principle of the Conservation of Mass and of Energy together can claim to represent the truth.

The Origin of Energies

A third great fact emerges when we inquire into the origins of all these forms of power that are familiar to us upon the earth. Till recently the scientific answer to this question was in the one word 'Sun.' The movement of the earth in its orbit is due to the gravitational action of the sun, operating on such momentum as the earth originally had when it was separated off from the great solar nebula, perhaps under the influence of a passing star. The tides are due to the differential attraction of sun and moon on the oceans, and it is unnecessary to consider the moon as very far apart from its parent, the earth. The energy of the waterfall or of the rapid stream depends on the energy of position which the sun gives to the mist that it raises from the sea. The energy of the steam-engine is derived from the accumulated sunshine of past ages stored in the potential chemical energy of coal and oil. The energy of the horse comes from the food which the green crops have built up by entrapping the energy of the yellow-orange rays of the sunlight. In every living creature there is an established organisation within which

there is an interplay of forces due to changes in surface tension, electrical charge, chemical composition, and so forth; but there is no special vital energy and no creation of energy by any organism. As far as matter and energy changes are concerned, the living creature is simply, though very wonderfully, a transformer. It changes its income of food into its expenditure of work. We shall speak of its mind later on.

But to this answer, that we owe all our powers of doing work to the sun, we must add another, which dates from Becquerel's discovery of radio-activity in 1896. In certain elements, like uranium, radium, thorium, there is a spontaneous disintegration of the nucleus of the atom, which gives off various kinds of rays at a high velocity.

This radio-active production of energy may come to be of value to mankind, though one cannot help hoping that the discovery may be delayed till man is more worthy of it; in the evolution of the physical world it has probably had a great rôle. All this energy of heat and light comes from the sun, but how does the sun have so much? The old answer was that the gravitational contraction of the sun produces more heat, some of which becomes light. As the sun radiates out heat and light age after age, it compensates for its loss by becoming smaller. The difficulty here was that this theory did not allow the sun that length of life which other considerations led

experts to demand. Still less would gravitational contraction account for the amount of light radiated from distant giant stars. The modern way out of the difficulty is to suppose that the reservoirs of energy in sun and star are replenished from sub-atomic sources, "as, for instance, from internal rearrangements in the positive nuclei of the atoms, or from the transformation of a small fraction of the star's mass into energy" (J. H. Jeans, *Cosmogony and Stellar Evolution*. Report Smithsonian Institution for 1921, p. 159).

We have spoken of the transformation of energy from one guise to another and of the unification of the energies in a vast series. We have spoken of the conservation of energy, that none can be created or destroyed so far as man can discover. We have spoken of the source of our earth's energy in the parent sun, and of the newly discovered fountain of power, which was unknown till the twentieth century, namely the liberation of the energy locked up in the nucleus of the atom. These are three fundamental ideas which must enter into the cosmic picture which the religion of the intellectual must seek to illumine.

Atomic Energies

We must return for a little to the structure and activity of the atoms to which we alluded in the preceding chapter. In the case of the heaviest atom,

Uranium, there are believed to be ninety-two outer electrons whirling round in ellipses; the centre, or "sun," of the system consists of two hundred and thirty-eight hydrogen nuclei and one hundred and forty-six inner electrons.

(1) The outermost electrons, as we noticed, take part in ordinary chemical reactions, such as combustion. The energy of these outer electrons may also take the form of light when the substance is incandescent, and this light may be studied spectroscopically, which is one of the ways of scientifically seeing the invisible. One must think of the outer ring of revolving electrons as mainly determining the chemical qualities of the element.

(2) When there is a disturbance of the inner rings of electrons, there is a giving off of X-rays, which are in the same series as visible light-rays, but with wave-lengths ten thousand times shorter. Just as there is a great gap between X-rays and ordinary visible light-rays, so there is another great gap between the wave-lengths of ordinary visible light and those used in wireless telegraphy. But all these are in one series.

(3) There is a dramatic interest in the emission of light by atoms, and in this connection there rises one of the most puzzling problems at present engaging the keenest intelligences in the world. At a great rate the electrons usually continue revolving round the nucleus, and then all of a sudden they

seem to do something else. Mr. Bertrand Russell compares the rapid revolution to the crawl of a flea, the point of the comparison being that the crawl is for a time continuous and then is suddenly interrupted by a jump. So with the electron, according to Bohr's theory. It suddenly jumps from one orbit into another much nearer the nucleus, and this means a loss of energy, just as happens if you shorten the string on which you are swinging a ball. But energy cannot be lost, and what the atom loses when an electron hops into a shorter orbit is gained by the surrounding medium in the form of light-waves.

To make an electron hop into a *larger* orbit, *i. e.*, pass from an inner ring to an outer, it is necessary to *give* it energy—by illumination, for instance. When an atom absorbs light an electron may be induced to jump into a larger orbit, *i. e.*, at a greater distance from the centre, and when it tends to return to its original narrower orbit it emits light exactly like that which it received, a glow whose cause is in the past.

It is an ingenious theory, whose verified predictions practically prove its validity, that when an electron jumps from one orbit to another, the atom gives off light; and the character of the light emitted differs according to the magnitude of the jump taken. But this jump seems to be at present one of the most puzzling phenomena in our wonderful world. It

seems to take place instantaneously, as if the electron could change from one orbit to another "without passing over the intermediate space." These are deep waters, but it is interesting and rather disconcerting that when continuity is being demonstrated all through the universe, there should seem to be a discovery of discontinuity in the heart of the atom.

(4) There is most energy, if we could only get at it, in the nucleus of the atom. We get a glimpse of this in radio-activity, and we see it liberated on a big scale in the apparently inexhaustible supply of energy that makes the sun the fountain of all mundane power. In his delightful *A B C of Atoms* (1923, p. 14), Mr. Bertrand Russell writes: "The nucleus of any atom except hydrogen is a tight little system, which may be compared to a family of energetic people engaged in a perpetual family quarrel. In radio-activity some members of the family migrate, and it is found that the energy they used to spend in quarrels at home is sufficient to govern an empire. If this source of energy can be utilised commercially, it will probably in time supersede every other."

The nucleus of the atom may in certain cases shoot out minute particles with extraordinary velocity, and this is what happens in the heavy atoms which illustrate the radio-activity discovered by Becquerel. When the nucleus shoots off these particles it changes its chemical nature. Thus, uranium may give rise to

ionium, which may give rise to radium. Or, again, thorium, radium, and actinium may each give rise to lead. Uranium may give rise to protactinium, which produces actinium, which produces lead. Or Radium by giving off Helium may produce lead. And thorium may do the same. Thus, there are three or four different leads: Actinium-lead, Radium-lead, and Thorium-lead, all the same in their chemical reactions and yet slightly different in internal structure. There is "ordinary lead" besides! It may be noted that while lead seems to be readily 'born' and does not die, there does not seem to be at present any process working the other way and producing heavy atoms like those of Uranium. We live in a time of the running-down of clocks. One would like to know how they were wound up, and whether the winding-up will ever begin again!

In the nuclear disintegration of the radio-active atoms, there is that extraordinary emission of particles and of light and heat to which we referred in the previous chapter. Let us recall the essential facts. There is a bombardment with alpha particles which are helium nuclei. In a little scientific toy called the "spinthariscope" we may see flashes struck off a screen of zinc-blende by the impact of individual helium particles shot out from a tiny speck of radium. Each helium particle is believed to consist of four hydrogen nuclei with two charges of electricity. But they have such a velocity (18,000 miles per

second) and they are so small that they can pass through glass, which has not time to break!

Then there are the beta particles, which are electrons, or negative units of electricity. Third, there are the gamma rays, which are next door to the Röntgen rays. And lastly, heat is given off, sufficient in amount if one had a big mass of radium or radium-salt, to raise the same weight of water to the boiling point every three-quarters of an hour. Such is a glimpse of the powers hidden in the dust!

The Quantum Theory

There is another great fact in regard to energy which must be taken account of in our survey, though it is too difficult to be dealt with except in a very superficial way. It is the fact expressed in the Quantum Theory, enunciated by Planck in the first year of this century.

The general idea is that energy is atomic in nature! That is to say, the energy emitted from a system or absorbed by a system is emitted or absorbed not continuously, but in little bundles, parcels, or quanta; and in any particular system, whether it be a heated iron bar or an atom of uranium, the quanta are all equal. They differ in different systems according to the frequency of the vibrations of the particles concerned. A quantum is just the minimum amount of energy a particle can possess.

As we have already seen, radiations are emitted

from atoms when an electron jumps from one orbit to another nearer the centre. The energy lost by the change passes out into space in the form of an electro-magnetic wave, the wave-length varying according to the rapidity or frequency of the vibration of the electron in question. But the quantum idea suggests that the emitted energy represented by the electro-magnetic wave comes out not continuously, but, so to speak, in spurts or discrete elements, all quantitatively equal for any particular case. A quantum, as we have said, is the minimum amount of energy that an electron can have, and the energy of an electron in any orbit of an atom is an exact multiple of a quantum. There are no fractions of quanta. The idea of the parcelling-up of energy enables us to understand why, when the illumination of a body is made to liberate an electron, it always sends it flying with the same velocity. Fewer 'parcels' of light mean fewer freed electrons, but the 'parcels' are all of the same size. The theory has been extraordinarily successful in clearing up a variety of puzzles and in prediction. Professor Bohr has used it, for instance, in predicting the spectra of various elements, and the exactness of verification is startling. Perhaps we should say that in the strict sense the quantum theory deals not with what one might call "atoms of energy," but with "atoms of action," the term "action" meaning energy multiplied by the time during which it acts.

Relativity

It is beyond our scope here to expound Einstein's Theory of Relativity, but the general ideas of the theory or closely associated with it are so important that they must be included in our outline picture. A connected statement will be found in the Appendix.

(1) The first idea is that only relative motions of bodies in the universe can be studied. On the deck of a liner we watch the game of shuffle-board. At a particular moment we see the player just about to make his stroke which will slide the disc along the deck. He is poised at rest. But it is obvious that he is only at rest in relation to the ship, and even that for a brief moment. He seems at rest, but the vessel has a complex movement, determined by the propeller, and also by winds and currents. But the earth is rotating on its axis, and is also revolving in its orbit round the sun. Moreover the whole solar system is moving with great velocity through space. How complicated the movements of the player standing at rest!

It is plain, however, that we could make a precise study of the path of the disc shuffling along the deck without troubling ourselves with the motion of the ship—if it was steady. Still less would we need to think of the movements of the earth. Similarly, we could make a precise study of the movement of the ship without concerning ourselves with the solar

system's stupendous journey through space. We study movements in relation to some body of reference supposed to be at rest.

But it was till recently believed that in optical and electro-magnetic phenomena we had to do with absolute movements through or in absolute space. This was believed to be filled with the mysterious ether. But modern experiments, notably those of Michelson and Morley, have been unable to demonstrate the reality of this ether, and the convenient hypothesis has become a scientific Mrs. Harris, many authorities coming to the conclusion "There ain't no sech person." But the abandonment of the idea of ether-filled absolute space has to be followed by giving up the idea of absolute time. Thus Einstein showed convincingly that our idea of "simultaneous events" is only relative; our perception of time depends on spatial measurements which are only known relatively. Time comes to be just a fourth dimension, along with "length, breadth, and height," in a four-dimensional world. Absolute measurements are impossible.

(2) A second great idea that is to be thought of along with Einstein's theory of relativity is that matter has been, so to speak, swallowed up by electricity. For, as we have seen, the atoms of matter consist of electrons revolving around a centre like planets round the sun; the centre consists of more whirling electrons and a number of hydrogen nuclei,

or protons; and these, according to some authorities, are simply unit positive charges of electricity. Now, if this be true, we reach the idea of electricity as the original unadulterated something—the warp from which, with mind as woof, all the worlds have been spun. Thus mass—the amount of matter in a body—is included in energy. This is a generalisation of the first order of magnitude.

(3) A third important step is that the Conservation of Mass (no destruction or creation of matter), established by Lavoisier, and the Conservation of Energy (no destruction or creation of any power), established by Joule, Mayer, and Helmholtz, become included in one principle. A long rod flying very rapidly through the air must appear shorter when in motion than when at rest, except indeed to a hypothetical airman travelling above the flying rod at the same high velocity; and the weight, or mass, of a rapidly moving body is shown to be influenced by its velocity, or, what comes to the same thing, by its kinetic energy. Conversely, a body that has its mass changed has its energy changed in proportion.

(4) A fourth idea is that Gravitation has been brought into line with the other energies—with the rush of a tornado and with inertia, with that motion of particles called heat, and with electricity, magnetism, and light. Faraday showed that electric currents were affected by a magnet; and, conversely, Clerk Maxwell showed that light is affected by a

magnetic current, a discovery which led on to the enunciation of the electro-magnetic theory of light. Einstein showed that light is deflected by the attraction of a large mass, like that of the sun, and this led to subsuming gravitation under the law of inertia. Just as a weight may warp the two-dimensional surface of a rubber balloon on which it rests, so, according to Einstein's theory the presence of matter in space causes a warping or strain in the four-dimensional manifold. This warping of the "world" has an effect on the path of a particle which moves into the disturbed region, and this effect is what is known as Gravitation. The fact observed at the 1919 eclipse that light from stars was deflected when passing near the sun, *and to the extent predicted by Einstein*, is a remarkable corroboration of the Relativity Theory.

(5) The theories of Einstein lead to the idea of a finite universe, the dimensions of which have actually been computed. Its circumference is estimated (very hypothetically) at about a hundred million light years, or six hundred million million million miles. This is ten times the distance from us to the farthest spiral nebula. The weight of the Einstein world is estimated at 10^{54} grams, or about a hundred trillion times the mass of the sun. We cannot, of course, *image* a four-dimensional curved world, with Time and Space interlaced, with when-ness and where-ness mixed, but there is no reason to boggle

over the question: If the universe is finite, what is beyond? So might a two-dimensional caterpillar, burrowing in the skin of an orange, say to itself: If I go on and on, I must come to an end sometime!

We do not pretend that we have given an account of the Theory of Relativity, but something of its gist may be inferred from thinking over five ideas: (1) That all measurements of movements are relative and that the concepts of Absolute Space and Absolute Time must be given up; (2) That it looks as if matter was going to be swallowed up by electricity; (3) That the Conservation of Mass and the Conservation of Energy may be included in one principle; (4) That gravitation has been brought into line with the other energies; and (5) That the universe is finite. These are elements in the present-day world-picture which must be religiously as well as scientifically appreciated.

The Outcome of Our Survey

What then is the outcome of our survey of the powers at work in the world?

(*a*) The picture is one of inexpressible grandeur, and yet, in a way, of extraordinary simplicity. Electrons, or negative units of electricity, and protons, or positively charged nuclei of hydrogen, are the building stones of the universe. The differences of kind that strike the observer so much at first sight depend on the differences in the number and disposition of

the electrons and protons. Similarly, as regards the energies there is great unification. Electricity, magnetism, and light are closely akin; heat is the motion of particles; the movements of bodies and the force of gravitation have come into line with the radiant energies to an extent greater than was dreamed of as possible two generations ago. The scientific picture of the world has become simpler and more unified; and this is, to say the least, *congruent* with the religious concept of God. The greatest artist uses fewest materials. Difficulties abound and puzzles there are many, but the lowest common denominator of the world becomes ever clearer—electricity and mind; or, more cautiously, matter, energy, and mind.

There is a basis for a rational wonder in the powers at work—in their forcefulness. A fiery jet from the sun may rise to a height of three hundred thousand miles; an electron may on occasions approach the velocity of light (one hundred and eighty-six thousand miles per second). What power there is in that grip that bears our solar system onwards through space several hundred miles since we finished the last sentence! What a vision of the enduring power of energy in the fact that light may travel to us from an inconceivably distant star, persisting on a journey which may take a hundred—even a thousand—years!

There is impressiveness in powers connected with immense distances and immense masses, but every-

where we find illustrations of the little things of the world confounding the strong. The greatest source of power is in the microcosm of the atom. Professor Millikan writes: "Nature takes a helium atom, which is going with a speed of eighteen thousand miles per second, and nature shoots that atom through a glass wall without leaving any hole behind and without in any way interfering with the structure of the molecules of the glass." This gives one a glimpse of the minuteness of the helium atom!

Our picture is of a world of power, for matter is being more and more swallowed up by energy. Matter consists of electrons and protons: but electrons are negative charges of electricity, and some would say that the protons, or hydrogen nuclei, are simply positive charges. We may legitimately entertain a feeling of wonder when we contemplate this world of energies.

The picture is a moving picture; all the world of energies is in flux. The water at Niagara tumbles tumultuously over a cliff of one hundred and sixty feet, attaining a velocity of a hundred feet per second before it reaches the bottom; its gravitational power is changed in part into heat, for the temperature of the water at the foot of the falls is one-ninth of a degree centigrade higher than it is at the top. But everyone knows how some of the water is led along tunnels and made to work dynamos, which change the energy into electricity, which gives light and

power in distant places. This kind of flux, which man controls, is paralleled all over the earth. Heraclitus said: All things flow; we may change it into: All powers flow. Nothing is lost, nothing is gained. The accounts always balance. The potential becomes actual, and the actual is locked up again in the potential, except that there is always some sinking down into the unavailability of diffused heat.

(*b*) The modern world-picture discloses a cosmos. Out of simple and uniform stones and mortar, and strikingly unified powers or energies, there has been built a glorious city, whose citizens we are. In view of the mischievous prevalence of the unhappy phrase "A fortuitous concourse of atoms," it is permissible to reiterate our impression of the orderliness of the world. We cannot think of an orderly cosmos coming out of a primeval chaos, and there is no warrant for believing that there ever was any such state of affairs. There are nebulæ in the celestial spaces today, but no astronomer would call them disorderly.

In a shaded room penetrated by a beam of light we see swarms of dancing motes, moving about because of the complex and variable conditions of temperature, because of draughts, because of vibrations on the windows, and so forth. We may call the dancing movements fortuitous, but that simply means that the conditions are too intricate to admit of exhaustive analysis. In his *New Physics* (1923, p. 44), Professor Arthur Haas speaks of the difficulty of

thinking of any actual order as the work of chance. "Many quadrillions of individual processes take place in the air of a room owing to the extraordinary smallness of the molecules. In the case of a system with such a tremendous number of individuals, if we wished to state the recurrence interval of a chance arrangement sufficiently large to be detectable by the senses, the number of years which determines the period would be inconceivably large. It would be so vast that if we wished to write it down on a strip of paper stretched between the earth and the moon, we should be a long way from having completed our task even when we had filled the strip. After what has just been said, how could the human mind comprehend the possibility that the order of the universe could have arisen by chance from the chaos of the irregular molecular thermal motion of our universe? But the incapacity of our mind to grasp it cannot constitute a proof against such a possibility. Not physics, but only philosophy can judge as to the justification of such an assumption. Modern molecular statistics has demonstrated the theoretical possibility of such an assumption, albeit only in connection with its *incomprehensibility.*"

(*c*) We cannot base a transcendent inference on finite experiences of Nature. No man by science can find out God. Yet a theistic conclusion is suggested when we try to think of the institution of the Order of Nature, of the original endowment of the irreduci-

bles with powers which change from form to form, of the grandeur of the long-drawn-out process of genesis, of the persistent urge of organic evolution—with many blind alleys and yet with an undeniable main line of ascent, and of the climax in Man. When we study the powers in the world, we find, as in other studies, that, as science advances, the world becomes more and more interpretable as the working out of a Divine Thought.

SUMMARY

(1) Primitive Man found himself in the grip of what we call Forces of Nature, which he had not begun to master or to understand. His primitive religious activities were probably moved by fear, helplessness, the instinct of self-preservation, and a feeling of mystery. He invested the powers of Nature with intention and tried to appease or cajole them. These were days of fear-religion and magic.

(2) It is interesting to contrast the crepuscular outlook of early man with the robustness and sober joyousness expressed in the Nature Psalms of the Old Testament, and in the poem of Job. The gulf is immense; and while it is true that hundreds of thousands of years separated the Nature Psalmist from Primitive Man, it was not merely a question of time; some present-day tribes remain at a very primitive level. There came about an emancipation; man had entered into his spiritual kingdom; even when afraid he was content; "God's in His heaven, all's right with the world"; there are terrible things indeed, but "the Lord reigneth." The relation of the Hebrew seers to Nature is unique; there has been nothing like it since. The characteristic feature is a detailed enjoyment or appreciation of the Natural World, both in

itself and as a revelation of God. Why should we not enter into an equally "original" relation with Nature?

(3) The modern change of temper—away from the old directness of religious interpretation—is due partly to the scientific disclosure of the Order of Nature, partly to an understanding that the Laws of Nature are descriptive formulations, partly to the acceptance of the idea of a natural evolution without extraneous assistance and without underpinning.

(4) The first great fact in regard to energy is its transformability. It changes from potential to actual and from actual to potential. It changes from mechanical motion to heat, from electricity to light, and so on in endless flux. The energies locked in the atom are liberated as heat and light and other radiations. The energies of Nature are all connected—though not without gaps.

(5) The unification of the physical energies has suggested to some minds the idea that God is the sum total of the energies of the world. It does not seem that the truth can lie along this line of thought, for an additive summation of physical energies remains physical. Even when the powers of life and mind are added, we have still to do with a sum of items which are scientifically known. The Vision of God is transcendental and mystical.

(6) A second great fact about energy is its Conservation. That no energy can be destroyed or created is an experimental induction, to which no exception is known. Energy is transformed from one guise to another, and some tends to sink down into the unavailable form of diffused heat. Although the fact of conservation stands secure within the range of our experience, it may be unwise to dogmatise about the universality of the induction. In any case, the use of such words as 'eternal' seems to be mixing up two languages.

(7) The source of terrestrial energies is found in the sun and, as regards the tides, to some extent in the attraction of the moon. Since Becquerel's discovery of radio-

activity, however, it has been clear that the spontaneous disintegration of the atom in radio-active elements is an inexhaustible source of energy, and this is the chief origin of the heat and light of the sun and of the radiance of the stars.

(8) In the planetary system of a heavy atom there are intricate transformations. (*a*) The outer electrons have to do with ordinary chemical reactions such as combustion. (*b*) When there is a disturbance in an inner ring of electrons, there is a giving off of X-rays. (*c*) When an electron of an outer ring suddenly hops into an inner ring, the energy liberated passes into the surrounding medium in the form of light-waves. (*d*) When there is disintegration of the nucleus of the atom there is an emission of (*i*) helium particles (alpha rays); (*ii*) electrons (beta rays); (*iii*) rays not very different from those of Röntgen, and (*iv*) heat. With this emission of energy there is a change in the chemical nature of the substance, as when uranium gives origin to radium, or when radium sinks down into lead.

(9) Very remarkable is the central idea of the Quantum theory, that there is an "atomicity" of energy in general, just as there is an "atomicity" of electricity and an "atomicity" of matter. When energy is emitted from or absorbed by any system, it is emitted or absorbed not continuously, but in little parcels or quanta, which in any particular case are all equal. A quantum is the smallest quantity of energy a particle can possess, just as an electron is the smallest amount of negative electricity that can exist. In the strict sense the quantum theory (see Appendix II) deals not with "atoms of energy," but with "atoms of action," the term "action" meaning energy multiplied by the time during which it acts. The old view may be compared to an old-fashioned clock whose minute hand moves continuously, though almost imperceptibly. The new view, expressed in the quantum theory, may be compared to the movement of the same hand in

an electric clock where there is a jerky transit from one minute dot to the next.

(10) The general ideas of the Theory of Relativity or closely associated with it are the following: (*a*) All measurements of movements are relative and the concepts of Absolute Space and Absolute Time must be given up. (*b*) Matter tends to be swallowed up by electricity. (*c*) The Conservation of Mass and the Conservation of Energy may be included in one principle. (*d*) Gravitation has been brought into line with the other energies. (*e*) The universe is finite and can be measured. These are elements in the world-picture, and they must be religiously as well as scientifically appreciated.

(11) The outcome of our survey is a picture of inexpressible grandeur, and yet, in a way, of extraordinary simplicity. There has been unification of the different kinds of matter and unification of the different kinds of energy. This unification is congruent with the religious concept of a Creator. In the scientific study of the powers of the world there is a secure basis for rational wonder.

Another fundamental impression is that of orderliness. The universe is a cosmos. We cannot think of it evolving from a primitive chaos and there is no warrant for believing that there ever was any such state of affairs. We cannot comprehend how the Order of Nature could arise from chaos and chance. The phrase "a fortuitous concourse of atoms" should be allowed to die.

We cannot base a transcendent inference on our finite experiences of Nature, yet a theistic conclusion is suggested when we think of the institution of the Order of Nature, of the original endowment of the irreducibles with powers which change from form to form, of the grandeur of the long-drawn-out genesis, of the persistent urge which is on the whole in a progressive direction, and of the climax in Man and his science. The advancement of the world reads like the working out of a Divine Thought.

CHAPTER IV

THE IMPLICATIONS OF LIFE

Emergence of Organisms on the Earth. The Criteria of Livingness. The Characteristic Qualities of Living Creatures: Victorious Insurgence. Intricacy. Effectiveness. Adaptiveness. Interlinkage. Beauty. Evolution. The Religious Interpretation of Animate Nature.

Emergence of Organisms Upon the Earth

SOMETIME or other, somehow or other, living creatures appeared on the earth, for before an uncertainly distant date, the surface was much too hot to allow of the existence of any organisms. The question rises: How did living creatures appear; and four answers have been suggested:

(1) A vivid impression of the marvel and mystery of life, especially in man, has suggested the answer that living creatures arose in a manner beyond the scope of scientific analysis. They were created by the word of His power. This is a good answer religiously, but it means a premature abandonment of the scientific problem.

(2) An appreciation of the uniqueness and apartness of living organisms, as compared with not-living things like stones and stars, has led some to a vigorous agnostic position: *We do not know.* Perhaps we

do not even know enough to put the question rightly. This answer is good scientifically, as long as it is accompanied by an active scepticism, and as long as the confession 'Ignoramus' is not allowed to become the dogma 'Ignorabimus.' It may be too soon to answer the question; it cannot be too soon to ask it, or to learn to ask it aright.

(3) It has been suggested by some distinguished men of science, notably Helmholtz, Kelvin, and Arrhenius, names sufficient to forbid a patronising smile at their hypothesis, that minute and simple forms of life may have come to the earth from elsewhere. They may have travelled in the crevices of a meteorite, sufficiently well wrapped up to withstand extreme cold in the journey through space and great heat as they approached the earth. The probabilities are against this theory, which would not, in any case, do more than shift the responsibility of the problem off the shoulders of this planet.

(4) The hypothesis most in accord with evolutionary thinking is that of the occurrence of abiogenesis in the dim and distant past. That is to say, simple living creatures may have arisen long ago by a process of natural synthesis from non-living materials—from some colloidal carbonaceous slime activated by ferments. In experiments made to-day there is no hint of abiogenesis or spontaneous generation of organisms, but *omne vivum e vivo* must not be made a dogma excluding the possibility of spontane-

ous generation long ago. Nor can it be regarded as certain that very minute living creatures, beyond the limits of visibility, may not arise to-day in appropriate conditions. As we have said, there is no evidence in support of this view, but we must not dogmatise. Some diseases may be due to germs (filterable viruses) which have never been seen. To those who are unfamiliar with any but the higher animals, and to those who appreciate the great gulf between the simplest living creatures and dead things, the hypothesis of the origin of the living from the not-living seems preposterous. Let us, therefore, state the pro's and con's.

(*a*) Everyone knows that the green leaf uses the energy of the orange-yellow rays of the sunlight to help it to build up complex carbon compounds, which are added to the capital of living matter. On this 'photo-synthesis' the whole system of Animate Nature depends, for the plants furnish food for animals. Obviously, however, the *living* leaf is an agent in this fundamental alchemy.

Everyone knows that the modern chemist, a little creator in his way, builds up out of simple materials such complexities as sugar, indigo, and salicylic acid. Even adrenalin, the potent chemical messenger or hormone discharged into the blood by the suprarenal bodies, has now been synthesised. It is plain, however, that the chemist often uses means, such as great heat, which are not likely to occur in Nature,

and that, in any case, he picks and chooses and arranges things. A rational being has a finger in the pie. What in the domain of lifeless things could fill the rôle of the chemist?

The edge has been taken off this difficulty by the suggestion that the cyanogen radical (CN) might arise in Nature in conditions of great heat, and that it, along with water and other readily available materials, would form a suitable beginning for synthetic processes which might lead to the proteins always found as essential constituents of living matter. *Ce n'est que le premier pas qui coûte.*

More important, however, is the recent work of Professor Baly and his collaborators, who have been able to mimic the photo-synthesis that occurs in the green leaf. Baly subjected water with carbonic-acid gas in it to prolonged illumination by a mercury-vapour lamp (giving out light with very short wave-lengths), and the result was formaldehyde (CH_2O), which is believed to be the first carbon-compound to be built up in the green leaf. With further illumination he obtained sugar, which is believed to be the second carbon-compound formed in the green leaf.

Using a quartz mercury lamp, Baly was able to induce the formaldehyde to unite with nitrites, thus forming nitrogenous carbon-compounds approaching the proteins which are characteristic of living matter. It will be noted that nitrites are readily avail-

able natural substances, produced, for instance, when lightning fixes the nitrogen of the air in the form of nitrous oxide and rain brings this down in the form of nitrite of ammonia. Man does something like this in fixing the nitrogen of the air by powerful electric arcs so as to obtain a basis for the manufacture of nitrogenous fertilisers.

If it be objected that the light used by Professor Baly consisted of wave-lengths much shorter than those of sunlight, it may be replied that the sunlight of long ago may have been a little different from that of to-day. But a better answer is afforded by later experiments in which Professor Baly got the same results as before by using ordinary sunlight in the presence of a "metallic photocatalyst," that is to say, a metallic substance which made the energy of the light more available. This is probably the function of the most important constituent in the complex green pigment (chlorophyll) which occurs in the leaf. The importance of Professor Baly's work is that he has approached the confines of living matter without using any material or means not readily available in Nature. With the help of light he synthesised nitrogenous carbon-compounds from carbon dioxide and water and nitrites. This may be said to be knocking at the door of abiogenesis.

(*b*) It may be pointed out that the problem before us is the origin of *organisms*—intact and independent individualities. This is a deeper problem than the

synthesis of protoplasm. There is no known occurrence of protoplasm in Nature except as the physical basis of life; it seems to be an intricate colloidal mixture of proteins, carbohydrates, fats, salts, and at least seventy per cent of water; it is the seat of oxidations and reductions, hydrations and dehydrations, condensations and fermentations—a routine of chemical processes summed up in the word 'metabolism.' Protoplasm is like a firm that owes its virtue to the inter-relations among the component partners. But it is quite fair to say that our problem is more than the origin of a subtle mixture of more or less complex substances; our problem is the origin of living organisms.

What can one say in the present state of science except that the integrative processes leading to protoplasm may have been continued into the integration of organisms? Perhaps the difficulty of the problem may be that the origin of organisms was a *psycho-biological* synthesis. Who knows?

It should be noted here that many of the lowest forms of unicellular or non-cellular life are very simple as biologists rank simplicity, and that the first organisms, probably invisible, were doubtless simpler still. What was primarily distinctive of a living creature was the capacity to remain for a time a going concern, building itself up as well as breaking itself down. The criterion was the ability to balance accounts, but it is likely enough that the first organ-

isms were literally creatures of a day. Perhaps they flourished in the tempered morning warmth of the sun, gave origin to others like themselves in the afternoon, and died in the chill of their first night.

(*c*) A third difficulty that may be brought against the hypothesis of the origin of organisms by natural synthesis is the absence of any trace of such processes in the world to-day. What is characteristic of the non-living world of to-day is that the clocks are all running down. But if abiogenetic synthesis once occurred, why should there be no trace of it continuing to-day? It would be too teleological to suggest that it is no longer needed, but it is possible that its occurrence demands a combination of happy circumstances no longer forthcoming in a more evolved world. It may also be that there are synthetic æons and analytic æons, as is also suggested when we think of inorganic evolution.

On a different tack, however, we may perhaps answer the question by asking another: Is it quite certain that the natural synthesis of organisms *has* stopped? Precise inquiry into what may be going on in quiet corners is still very young. There seems good evidence of the existence of organisms (some of the filterable viruses) so small that they cannot be seen. Moreover, the experiments that are made to expose the fallaciousness of alleged cases of the sudden abiogenetic appearance of highly evolved Infusorians, Rotifers, and the like, obviously involve

conditions in which organic synthesis would not be likely to occur.

It does not seem to us that there is much reason to expect the present-day synthesis of very simple organisms from not-living materials, but it is not scientifically justifiable to deny the *possibility*. Finally, it should be remembered that if living organisms did once arise from non-living antecedents there was probably a process of winnowing out the failures and relative failures. There is a picturesque touch in Sir Ray Lankester's suggestion that the first organisms to succeed may have fed on antecedent stages in their own evolution. It is more probable, however, that the first organisms were "traps that caught sunbeams."

We have stated the chief objections that can be urged against the view that the living may have had its origin in the not-living, and the question is plainly one that cannot be answered at present with any security. Even if we say *Ignoramus*, there is a slight *suppressio veri*. It must be admitted that the general trend of *opinion* is in favour of the evolutionist idea that there has been continuity of process from the whirling nebula to the earth revolving round the sun, and from the cooling earth to awakening life, and from simple organisms to tentative men, and from groping Hominids to *Homo sapiens*, who has lived and lives at many levels. To our scientific thinking this continuity of process implies

that, in Animate Nature at least, mind is the warp of the fabric to which protoplasm contributes the woof, and we are personally inclined to carry the "double-aspect" view throughout, from "first" to "last," if such words may be used. Speaking religiously, we believe that behind all there is the supreme reality of the Divine Will.

To many minds the hypothesis of the emergence of the living from the not-living seems to jettison the dignity of life. But neither historical origin nor individual development can affect the value of an outcome. The flowering plant's beauty is not affected by its origin from a flowerless ancestor; the flower's beauty is not touched by the fact that it was once latent in an inconspicuous bud.

If living organisms emerged from air, water, and salts on which the sun shone to some purpose, then we must credit the non-living with a richer promise and potency than was dreamed of by our forefathers.

We venture to quote in this connection what has been very wisely said by Professor Lloyd Morgan in his *Interpretation of Nature* (1905, p. 77): "Of protoplasm we may likewise say that under certain conditions, at present unknown, it appeared. Those who would concentrate the mystery of existence on the pin-point of the genesis of protoplasm do violence alike to philosophy and to religion. Those who would single out from among the multitudinous differentiations of an evolving universe this alone

for special interposition would seem to do little honour to the Divinity they profess to serve. Theodore Parker gave expression to a broader and more reverent theology when he said: The universe, broad and deep and high, is a handful of dust which God enchants. His is the mysterious magic which possesses—not protoplasm merely, but—the world." But those entirely misunderstand the situation who think that we are, in an appreciation of this religious position, in any way exonerating ourselves from inquiry into the possible genesis of protoplasm or into an analysis of its chemico-physical qualities.

The Criteria of Livingness

There is not as yet any clear understanding of the secret of the living organism, but it is possible to indicate certain criteria. Following a previous statement of these (*System of Animate Nature*, 1920, p. 79) we may arrange them in three groups of triads:

(1) A living creature always exhibits, though it has its periods of relative rest, a routine of chemical changes (metabolism), which involves especially an up-building and down-breaking of protein substances. (2) This protein metabolism differs in detail in different kinds of creatures; it is *specific;* it has an individuality. There are a great many different kinds of proteins, and there is a static as well as a dynamic side to this specificity. Thus a lining cell from the windpipe of a horse is different in micro-

scopic architecture from a similarly situated cell in a cow, and the blood crystals of a dog are different from those of the nearly related fox. (3) In spite of ceaseless change, the living creature remains practically the same for an appreciable time, which varies greatly in length in different organisms. Some insects are adults only for a day; the Big Trees may survive for two thousand years; but for all organisms the emblem is the Burning Bush—always burning away, yet never consumed. The capacity for retaining integrity is characteristic of organisms.

(4) It is characteristic of living creatures that they are able to accumulate energy acceleratively. They are able to store or capitalise. This leads on to organic growth, an integrated increase of the living substance at the expense of material quite different from itself, whereas a crystal typically grows from material the same as itself. (5) But growth leads on to the power of multiplication, which is often very plainly discontinuous growth. (6) And when a part is separated off to start a new individual it shows a power of development. Whether it be a bud or a germ-cell that is separated off from a parent there is an actualisation of the implicit, a realisation of potentialities. Out of the apparently simple there comes the obviously complex.

(7) Living creatures show effective self-preservative response to outside stimuli, but they are also able to assert themselves as agents. They have a

capacity for behaviour at many different levels. (8) In the course of their activity, organisms show a characteristic power of enregistering experience, of which there are only dim adumbrations in non-living objects. The past of an organism lives on in its present. (9) From generation to generation organisms show a capacity for variation. They are in a state of flux. The offspring are not always replicas of their parents. Living creatures are fountains of changefulness. Evolution is characteristically creative.

The nine key-words are—Metabolism, Specificity, Persistence; Growth, Reproduction, Development; Behaviour, Enregistration, and Variability. It is not to be supposed that there are not in not-living Nature certain features which are in line with those here emphasized as criteria of livingness; but the synthesis of these criteria in organisms is unique.

Living is a kind of activity, and the life of an organism shows action and reaction, thrust and parry, between the organism and its environment. At one time the organism takes the initiative, acting on its environment; at another time the environment takes the organism in its grip and stimulates or moulds it. Thus, as Professor Patrick Geddes clearly points out, a descriptive definition of living might be condensed in the fraction:

$$\frac{O \rightarrow f \rightarrow e}{E \rightarrow f \rightarrow o} \quad \begin{array}{l}\text{(Organism} \rightarrow \text{function} \rightarrow \text{environment)}\\ \text{(Environment} \rightarrow \text{function} \rightarrow \text{organism)}\end{array}$$

At certain times and in certain types the numerator of the fraction $\frac{\text{Ofe}}{\text{Efo}}$ is more in evidence; at other times and in other types the denominator is the more conspicuous feature. This is a very useful generalisation, and its truth is verified even among men, who accentuate the Organismal or the Environmental in their moods and morals, in their practice and philosophies. What we sought to analyse in the previous part of this paragraph was the differentia of the organism as contrasted with crystal or star, cloud or whirlpool. Life is a particular kind of activity which is marked by the synthesis of the nine qualities grouped in the three triads. What Professor Geddes's fraction gives us is a generalised description of living.

A final note in this connection may be useful, that when we compare a living organism with a non-living material system, we must make a special comparison for machines. For a machine is not a fair sample of the non-living world, since it is a collocation devised and arranged by human reason. There is in a certain sense inside every machine a human idea that distinguishes it from stone or star. Like a machine the living organism is a transformer of energy, but it differs from a machine in being self-stoking, self-regulating, self-repairing, self-increasing, self-multiplying, and so on till we reach ourselves, who are self-conscious. The comparison of an organism with a machine is useful and instructive, but we must realise what the comparison implies. A machine is a human collocation, not a natural object.

The Characteristic Qualities of Living Creatures: Victorious Insurgence

One would think that it should be impossible for a normally constituted human being to take a cold-blooded view of life. Expressed in multitudinous forms, from the invisible microbe to the gigantic whale; from a relatively simple jellyfish trailing for thirty feet in the sea, to a beetle less than a hundredth of an inch long, yet an intricate system of organs, tissues, and cells; from the half-awake routine of a tree to the intense bustle of the soaring lark; what variety there is in that kind of activity which we call life! What are the general impressions that remain when particulars fade away? What are the outstanding features of the System of Living Nature?

Our first impression is that of victorious insurgence. Tennyson lingered by the pool in the wayside stream, scrutinising the diverse animals swimming and swaying there, and said as he turned away, "What an imagination God has." There are over twenty-five thousand backboned animals named and known, and over two hundred and fifty thousand backboneless animals. Even the numerical strength of life is astounding. No one can forget Spenser's lines:

> "But what an endlesse work have I on hand,
> To count the seas abundant progeny,
> Whose fruitful seede farre passeth those on land,

And also those which wonne in the azure sky;
For much more eath to tell the starres on hy,
Albe they endlesse seem in estimation,
Than to recount the seas posterity;
So fertile be the floods in generation,
So huge their numbers, and so numberlesse their nation."

Not less striking in many cases is the number of individuals. Life is like a river that is always overflowing its banks. In a bucket of water drawn from the open sea there may be more representatives of one kind of animal than we can see of stars on a clear night. One of the starfishes (Luidia) produces two hundred millions of eggs every year, and yet is not very common.

But the note of victory is sounded in much more than multitudinousness. We hear it in the peopling of every corner of land and sea. Life is practically ubiquitous; it will not be denied entrance. It always reminds us of a river in flood, slowly spreading inch by inch beyond the confines of its bed, filling up every crevice, forgetting no corner. Thus we find some animals at an altitude of ten thousand feet on Monte Rosa and others in an oceanic abyss, six miles below the surface. The briny waters of the Great Salt Lake have their two or three different kinds of tenants; the hot springs and the dark caves have likewise their inmates. A single stone from the floor of the sea may have fourteen different kinds of moss-animals (Bryozoa) growing on it, and a single tree in the middle of a field may be the headquarters

of fifty different kinds of animals. No niche of opportunity is left unoccupied, even when it seems to our eyes very unpromising. Life is insurgent. There are scores of strange haunts that are almost incredible—a spider spinning its web inside a Pitcher-Plant, or a salamander up a tree, or a rich micro-fauna and micro-flora under fifteen feet of ice on the edge of the Antarctic Continent. Who cannot but be impressed with the big fact of oceanography that there is no depth too deep for life? It seems a very inhospitable haunt—the floor of the Deep Sea, miles below the surface, subjected to enormous pressure of many tons on the square inch, an eternal winter, an utter darkness apart from the fitful gleams of phosphorescent light, a calm, silent, monotonous world, a plantless realm, yet tenanted by a great variety of animals, well-adapted, vigorous, beautiful. We know life to be insurgent.

Intricacy

A second impression is of intricacy. Man is fearfully and wonderfully made. We never fail to be impressed with an intricate mechanical device, such as a linotype printing-machine, a loom, a calculating-machine; and we praise the maker. Why are we not more generous in our admiration of a living creature, which is more than any machine? Why are we not more inclined to do homage to the Prime Mover, who made things make themselves?

We are confronted, then, with the intricacy of life. We have twenty-five trillions of red blood corpuscles and four billions of white blood corpuscles, and each is a living unit of great complexity. The microscopic capillaries, which Harvey inferred and Malpighi demonstrated, connecting the ends of the arteries with the beginnings of the veins, are so numerous that if those of our body were placed end to end they would stretch across the Atlantic; and a drop of blood, if we could suppose it to retain its individuality, has a journey of about a mile a day. The nerve-cells of our cerebral cortex, the seat of the higher intellectual processes, weigh no more than half an ounce, yet there are nine thousand, two hundred millions of them, between five and six times the number of people living on the earth. And each cell is a complex intricate living unit often like a busy telephonic exchange, receiving calls and bringing one part of the body into communication with another.

How glibly we say 'a single cell'; but a cell is a little world in itself. The living matter is in a colloidal state; that is to say, it shows a motley multitude of jostling particles and immiscible droplets suspended in a fluid, and divided somehow into eddies so that diverse chemical processes can go on at the same time side by side. In the cell-substance there are, in many cases, strands and rods and other definitely formed bodies, which are of at least three

different kinds and bear many different names—as long as the things themselves are minute—such as mitochondria, chromidia, and Golgi's apparatus. In many animal cells there are two minute central corpuscles, or centrosomes, which play an important part as weavers at the loom when the cell is going to divide into two. In the centre of the cell-substance, or cytoplasm—a whirlpool of eddies, with its diverse flotsam—there floats the nucleus, a little world in itself. Inside its membrane, through which materials are ever permeating out and in, there are the readily stainable chromosomes, usually definite in number for each species. Thus the number for man is probably forty-eight. But each of these rodlets, or chromosomes, is built up of microsomes, like beads on a string. Our head begins to reel—body, organs, tissues, cells, nucleus, chromosomes, microsomes, and beyond that, though we cannot see, there are smaller units still.

The cells form the stones and mortar of the house of life, but that is too static a metaphor, for they are *alive*. Each cell is like a firm—cytoplasm, nucleus, centrosome, mitochondria, and so on, being the partners; and the success of the firm depends upon the way in which the various partners work into each other's hands in harmonious inter-relationship. A cell is a whirlpool of complex chemical substances—proteins, sugars, fats, and so forth—but there is no disorder. It is not a witch's caldron. It is a labora-

tory in which there take place oxidations and reductions, hydrations and condensations, up-building and down-breaking changes. The reactions take place with great speed, which means that ferments are at work, and with not less extraordinary orderliness. It is evident that we are fearfully and wonderfully made.

Huxley compared the living body to the great whirlpool in the course of the rapids below Niagara Falls. At a bend in the river an immense (sixty acres) bowl has been carved out of the cliff on the Canadian side of the river, and in this the water has been circling round much in the same way since man first described the Falls. There is incessant change and yet the whirlpool remains the same. Water is passing in tumultuously and equal quantities are passing out, yet there is relative constancy; and the flotsam of branches and twigs—or it may be ice—is often leisurely in its circling. So the living body is a whirlpool of proteins, carbohydrates, fats, and other substances, undergoing ceaseless change and yet retaining a relative constancy of form—for days or months, for years or stretching cycles of years. It is a mere guess that the human body is wholly changed in the course of every seven years, but the whirlpool of the body is a useful metaphor. It must not be pressed too far, however, for the whirlpool of the body has the power of gathering itself together and acting on the environmental

stream; it has the power of giving rise to other whirlpools like itself; and it sometimes gives unmistakable evidence of having a mind of its own.

An apprehension of the intricacy of the living body leads some to leap hastily to an anthropomorphic transcendentalism. They infer that this extraordinary bustle of complex vital processes, as orderly as it is crowded, must be specially sustained by the Power of God. Yet the probability is that this line of thought is mistaken. Is there not a suggestion of some imperfection and inadequacy in the objective creation if the Creator has to assist the work of His hands with continual underpinning? A stronger philosophy is indicated in Charles Kingsley's immortal *Water-Babies*. When the child at length came to Mother Nature, and, expecting to find her very busy, was surprised at her folded hands, he received a wise answer to his natural question: "You see, I make things make themselves."

In objecting to the idea of underpinning, or the secondary subsidising of natural processes with grants from a spiritual Treasury, we are not departing from our belief in God as "the constitutive principle of the Universe," "the source and home of all the order." Nor are we pretending, speaking for ourselves, that we have any conception of the relation of God to the world, except that it must be subtler than underpinning suggests. Perhaps it would be clearer to say that behind all there is *the Will of God.*

But if we use this simply as a verbal formula, it is perhaps only a little better than any other.

Effectiveness

A third big impression is that living creatures are in varying degrees effective agents. The movements of the stars in their courses are sublime, but the movements of the whirligig beetle in the pool are on a higher turn of the wonderful. The whirligig beetle does in some measure command its course; it is in some degree a free agent.

Living means in part a capacity for effective self-preservative response. A barrel of gunpowder responds effectively to a spark, but it is a suicidal efficiency. The animal has also its oxidations or explosive combustions when it acts, but it retains its integrity for days or years. The main tendency now observable in non-living Nature is towards disintegration of matter and degradation of energy. Radium sinks down jerkily towards lead as surely as the mountains flow down to the sea; and living creatures cannot but illustrate the same running down of the clock. But the point is that they are also able to wind themselves up. There is anabolism counteracting catabolism. The aboriginal living creatures may have been very short-lived, but they were never like rockets. What made persistence possible was the primitive protoplast's utilisation of certain rays of sunlight to build up carbon-compounds from car-

bonic-acid gas and water; and the whole economy of the animal world depends ultimately on the photosynthesis effected by the green plants. The energy of bird and butterfly is literally transformed sunshine.

In thinking of the free agency of living creatures, we must avoid three common errors:

(1) A living creature cannot make any energy; like an engine it is only a transformer. The measurable energy of an animal is not anything created; it depends on the chemical and physical energies of the living matter and on what it incorporates in the way of food and oxygen. In the colloidal nature of living matter and in the surface phenomena of the units or cells there are arrangements which facilitate the transformation of energy, but there is no evidence of any fresh production of power. Of mental energy we shall speak later, but in all its movements and operations the animal is simply a transformer of energy. Characteristically, however, it is able to transform energy to its own advantage; its responses are effective and self-preservative; it does things and keeps agoing. In the doings of living creatures there is often some degree of purposiveness —though it is always below Man's rational purposefulness, and often below man's intelligent purposefulness.

(2) While we remain personally unconvinced by the arguments of the positive vitalists, who maintain

the reality of a special "vital force," we hold to a "methodological vitalism" which asserts the autonomy of the organism. That is to say, no complete vital phenomenon, not even the contraction of a muscle, has yet received adequate description in terms of chemistry and physics. It is necessary to use special biological categories, such as the organism's power of enregistering its experience within itself so that it influences subsequent behaviour. Similarly, with growing, reproducing, developing, varying, and other vital qualities, they appear to us to be ultra-mechanical. In short, organism is more than mechanism; compared with the not-living, it is a new synthesis.

There is, no doubt, a chemistry and a physics of the organism, absolutely indispensable, but when they are added up they do not give biology. The chemico-physical formulæ are insufficient for the adequate description of distinctively vital activities, and, from the nature of the case, they must still more egregiously fail to grip when "mind" is an appreciable factor.

(3) A third error is in overlooking the prevalence of constitutional obligations among living creatures. It has been, so to speak, a policy of Animate Nature to enregister the capacity for the automatic performance of frequently recurrent activities. In other words, those animals got on best that came to have, as part of their hereditary constitution, certain pre-

arranged connections between particular nerve-cells and particular muscle-cells. It was a time-saving and a life-saving acquisition to have inborn reflexes like sucking and swallowing, inborn tropisms like moving up or down, towards the light or away from it; inborn instincts like breaking out of the egg-shell or seeking nectar from a flower. In many cases it must be admitted that animals are constitutionally compelled to do certain things; they behave like automatic agents, and if the normal conditions of their life are suddenly changed, they may work out their own destruction, as when the moth flies persistently into the flame of the candle. In many cases, however, it is plain that the constitutional engraining leaves the creature more free for experiments and adventures at a higher level, sometimes truly intelligent.

There is a high degree of obligatoriness in most reflexes, such as sneezing, and many of them can occur without any assistance from the brain. A turtle's heart will beat in response to a touch though the bulk of the animal was made into soup some hours or days before. Some of the lower animals, like sea-urchins, have been described as "republics of reflexes."

Similarly, the moth flying near the candle is constitutionally and automatically compelled to adjust its body so that its two eyes are equally illumined, and in certain conditions this obligation brings it

inevitably into the flame, which is, of course, a very unnatural stimulus. If it were flying less quickly, the "tropism" to fly away from the heat would prove stronger than the "tropism" to adjust its body so that the eyes are equally illumined, but when it is flying quickly there is no time for that, and the dominant tropism carries the creature to destruction.

Similarly, at a higher level, the full-grown Procession Caterpillars are instinctively compelled to crawl straight on until they find a soft patch of soil into which they can burrow and within which they will undergo metamorphosis. It is a useful 'instinct,' but if a boy directs the head of the leader of the Indian file so that it touches the tail of the last in the procession, they will go on for hours in futile circumambulation. They are obeying an instinct which works well in ninety-nine cases out of a hundred. The somewhat dull-witted lemmings illustrate a similar tax on entailed routine when their instinct to march straight ahead when they are trekking leads them to swim out into the sea.

The advantage of these hereditary entailments or enregistrations is obvious. They enable the organism to give an immediate response without hesitation or experiment. How inconvenient it would be if the nestling were not reflexly wound up to respond instantaneously to the touch of food in its mother's bill! How fatal it would be if the newly hatched

Mound-bird, without the presence of any careful parent, did not instinctively clamber out of the heap of fermenting vegetable dêbris and hurry off into the scrub. How difficult the situation if the young worker-bee emerging from the semi-darkness and inexperience of the hive into a world of sunshine and flowers had to *learn* to find its way about.

It is part of Nature's tactics, so to speak, to enregister certain capacities for routine activity, thus saving time and fatal fumbling, besides leaving the 'mind' free for some measure of intelligent adventure. In other words, up to a certain level those animals got on best that had a repertory of ready-made capacities. The tax to pay on this entailment is the frequent inability to make a fresh adjustment when the circumstances are slightly altered; but we take a wrong view of the effective agency of animals if we make much of this occasional breakdown. When the circumstances are relatively constant within a limited range, as in the life of many insects, the inborn instincts work extraordinarily well, and they leave a measure of freedom to what there is of mind. If a pigeon's brooding has been for thousands of generations "in charge of instinct," if the phrase may be permitted, it is a misunderstanding on our part to call the bird stupid because it sometimes continues sitting on an empty nest without attempting to retrieve the two eggs which have been removed a couple of inches to one side. An analogy may be

found in the methodical habituations of a very busy man; they leave him free to attend his mind to more important affairs, but there is occasionally a tax to pay when something very unusual disturbs the accustomed sequence of circumstances.

Adaptiveness

To our impressions of the insurgence, intricacy, and efficiency of living organisms, we must add that of *adaptiveness.* A living creature is often very markedly a bundle of adaptations, meaning by that, that its structures and functions are often in some particular way suited or adjusted to particular uses or circumstances. Every organic structure or function that is normally a useful part of the organism, and not a mere decoration or exuberance, must be fit. It must show a general adaptedness. Thus a bone that is not hard is in most cases out of the question. But within the general adaptedness of the bony skeleton, there are hundreds of special adaptations—an internal architecture that resists peculiar strains and stresses; a breakage-plane up the middle of a vertebra in a lizard's tail, so that the surrender of a member to save a life is easy; a smooth round knob on the head of the thigh bone to allow of ready movement in a deep socket; a keel on the bird's breastbone for fastening on the muscles of flight; or an arrangement of levers for raising the fangs when the cobra is about to strike.

As a great naturalist once said, when you take away the adaptations from a whale there is not much left. What a huge bundle of adaptations: the torpedo-like shape of the body, the frictionless skin, the buoyant blubber conserving the animal heat, the tail-flukes forming a propeller that works so effectively without turning round, the balancing flippers, the valved nostril or nostrils on the top of the head, the sponginess of most of the bones, the solidifying of the short neck, the spacious lungs, the usual reduction of the offspring to one at a time; and the special milk-reservoirs which give the baby a big mouthful at a gulp. These are more or less obvious adaptations, but for one that is obvious there are ten that are subtle.

Sometimes the nicety of the adaptation is most striking when a single structure is concerned. We get the impression that the ages required are of little importance when perfection is the goal. It may have taken a million years to evolve a feather, which is one of the most perfect structures in the world. A single pinion from an eagle's wing has nearly a million different parts. It consists of the quill and the shaft, and the two rows of barbs on the shaft, and the two rows of barbules on each barb, and the numerous barbicels on the barbules. The whole is a sail that strikes the wind, firmly and yet elastically, not letting the air through the web and yet not getting broken. It enormously increases the bird's power

of rowing in the air, and yet how little it adds to the weight. As long as it is growing it is fed; when the constitutionally ordained limit is reached it stops growing and yet does not die too quickly. When it dies it is moulted off and a new one takes its place, often just in time for the migratory journey, when frayed feathers might be dangerously ineffective. And this is not nearly all, for the feather is difficult to wet, it forms part of an admirable non-conducting robe conserving the precious animal heat, and it is often so coloured that it gives its possessor a garment of invisibility. And this is not all, for we may admire the neat way in which the feathers are feathered when the wing is raised for the next stroke, so that energy is economised just as in rowing. And even the fallen feather may form part of the best of quilts for keeping the young ones snug within the nest. We need not elaborate the subject; we wish merely to suggest the perfection of detail in many of these adaptations. We might say that there is no sparing of time or pains, were we not aware that time does not count and that no pains are taken.

Take one of the almost bizarre examples that make Zoology such an inexhaustible well of surprises. There is an African snake called Dasypeltis, which has the habit of eating birds' eggs. It is very poorly equipped with teeth, which are just sufficient to grip the egg, first with one side of the mouth and then with the other. Gradually the egg, all unbroken,

comes into the grip of the pharynx and begins to slide down the gullet, which it greatly distends. But as it passes down it is pressed against the sharp tips of the inferior processes of a number of vertebræ which actually protrude into the cavity of the gullet. They are said to be tipped with enamel, and they break the egg-shell very neatly. Not a drop of the precious contents is lost, and there is a touch of perfection in the way in which Dasypeltis "returns the empties," considerably broken, it is true.

In the days when the idea of transformism had not been more than mooted, those who studied the adaptations or fitnesses of living creatures regarded them not unnaturally as the direct work of the Creator, who was often given the rather terrible title of the "Divine Artificer." "He that formed the eye, shall He not see?" In the first phase of this way of thinking, God was the certainty, and it was with a genuine piety that men traced the work of His fingers. Perhaps this was a sounder view than that which afterwards arose, in the "Argument from Design" period, when learned men argued from the fitnesses of the human hand to the reality of the Divine Hand, or worked up from Nature to Nature's God. This was the time of Paley and the Bridgewater treatises.

There are two fatal objections to Bridgewaterism. The first is that the data of science cannot furnish a basis for the transcendent inference that there is a

God. They may suggest the belief, strengthen it, even ennoble it, but they cannot be its foundation. We may infer a man from a linotype machine and the analogy of our own human nature, but we cannot base a belief in God on all the wonders of creation. There is another question: whether the existence of Science does not in itself imply the existence of God, but that philosophical question is not raised in the "design argument."

The other obstacle that the Bridgewater argument had to face was the growing evolutionism. For even before Darwin, naturalists were beginning to show how adaptations could be naturally accounted for; and Darwin advanced a thought-out theory. Given a sufficient crop of heritable variations—and there is often a prolific crop; given the subtle sifting in the struggle for existence, which has often a very fine mesh; given the hereditary entailment of the useful new departures, then, said Darwin, the finest adaptations can be accounted for. Perhaps Darwin, self-critic as he was, had greater confidence in his evolutionist account of the origin of fitnesses than most of his followers have to-day, but that is not a point of radical importance. The big fact is that the natural history of adaptations *is being* worked out; and the argument from design must change into a recognition of the wonder of the way in which things make themselves, and into the recognition of a Divine Purpose in the institution of the Order of Nature.

Interlinkage

We have spoken of the insurgence, the intricacy, the efficiency, and the adaptiveness of living creatures. Another large impression is the tendency to interlinkage; it seems to pervade the whole of Living Nature. Expressed in generalised terms, it is a tendency to the correlation of organisms, to the binding of life to life, to the formation of an external Systema Naturæ.

This is a central Darwinian idea, that nothing lives or dies to itself. One life-circle intersects many others; every creature, as John Locke recognised, is a retainer to some other parts of Nature. One often gets the impression of a coherent fabric, and one is missing the point altogether if one finds any inconsistency in the fact that one thread in the web may find its sustenance in another.

As we have said elsewhere (*Science Old and New*, 1924, p. 429): Earthworms plough the fields; the bees and the flowers are hand and glove; the mistle-thrush plants the mistletoe; the minnow nurses the mussel; the water-wagtail helps the sheep-farmer; and the squirrel may have its share in making the harvest a success. Suppose the glory that was Greece was in part dimmed by the obtrusion of malaria, as some historians say; the disease is sown by mosquitoes; the aquatic larval stages are very effectively checked by minnows. Well may one exclaim: "Ye gods and little fishes!"

It is not enough to recognise the web of life as one of the great facts of Animate Nature; we must see how it works. The gradual complexifying of the inter-relations of an organism means that new departures will be tested in regard to a sieve which has a certain stability, having stood the test of time. This makes it easier to understand how it may come about that minute new departures have survival value. They are sifted by a subtle sieve and by a sieve that is evolving as well as the material that is sifted. As inter-relations are multiplied and tightened the sieve becomes more subtle and testing. Even a shibboleth may determine survival.

In the course of organic evolution there have been retrogressions and degenerations, especially when animals have accepted the open door of parasitism—perhaps all the more seductive because it is a kind of vital linkage and is often, as it were, next door to partnership. But parasitism—common as it is—is little more than incidental when compared with the big fact of progress. Whatever word is used, there has been an advancement of life through the ages. But it is not very easy to answer the question, How has this generally progressive tendency in evolution been secured? Part of the answer, we believe, is to be found in the external Systema Naturæ, in which life is linked to life, so that they stand or fall together. Flowers and insects have become very intimately linked together, and it is plain that retrogressive change in a flower will be less likely to gain ground

since specific insect-visitors are also involved, and if they are excluded the variant plants may be doomed. Similarly, a variation in the mouth-parts of an insect is not likely to succeed if it prevents the utilisation of the favourite flowers. As in human affairs, so in the realm of organisms, a complexifying or a tightening of inter-relations tends to prevent slipping down the rungs of the steep ladder of evolution.

Beauty

Another dominant implication of life is the practical omnipresence of beauty. There is, of course, an abundant wealth of beauty in the inorganic world—with its diamonds and dewdrops, the scenery of the earth and the cold glory of the stars, but beauty is even more dominant in the realm of organisms.

We believe in a definite objective basis of beauty—certain qualities of lines, colours, and movements; but we cannot define these qualities except subjectively, by saying that they excite in us a distinctive æsthetic emotion. Experiments show that unsophisticated people, like children, give a preference, when selecting shapes, to an ellipse with its axes in the 5:3 proportion, the famous "golden section." But why this shape should be a favourite, we cannot tell. It is possible to understand certain negative limits: that the shape should not be a conundrum, that the colours should not be muddy, that the movements

should not be fumbling, and so on; but why a certain plant or animal should command the unanimous delight of all who see it, that we cannot explain in spite of much æsthetic analysis. A thing of beauty is a joy for ever, that is the definition. Accompanying the æsthetic emotion there is a pleasing physiological thrill penetrating the body, and in many cases there are perceptual and conceptual associations which strengthen feeling. But, without seeking to dogmatise on a difficult problem, we hold to the thesis—that there is an objective basis for beauty. In other words, when allowance is made for previous pleasant experiences, for associations established, for strings subconsciously struck, and so forth, the greater part remains unexplained. We delight over an animal from the Deep Sea which was never seen before and is unlike anything else. The artist gloats over an organism of which he has no scientific understanding. We see a domesticated animal or cultivated plant change from beauty to ugliness under man's fingers. We are often thrilled by the beauty of an animal, such as a snake, which is in its associations repellent. These are merely hints of some of the reasons which lead us away from the generally accepted view that the presence or absence of beauty depends on ourselves alone.

Apart from domesticated animals and cultivated plants, which are often spoiled by man; apart from crippled, diseased, or parasitised organisms; apart

from the thoroughgoing parasites which often bear the stigma of dishonour; apart also from some unfinished organisms, hidden away in embryonic wrappings, all living creatures seen in their natural surroundings are things of beauty. Of course there are different degrees of beauty; not unnaturally, since some organisms are younger and less perfected than others. One must also admit that there is beauty that is difficult and beauty that is easy, just as with pictures. But, apart from the exceptions stated, the quality of beauty is everywhere, internal as well as skin-deep, and microscopic as well as conspicuous.

Beauty seems to be an expression of orderly harmonious living; it implies unity of life, from which the discordant has been sifted out. It is the outcrop of a bodily routine that is consistent, that has stood the test of time. Beauty is sometimes an expression of vigour, sometimes the efflorescence of the inner psychical life. It may be a simple matter—the ripple-marks of rhythmic growth; or it may be a very subtle triumph of life over materials. It is much more than handsomeness, much more than fine workmanship, much more than fitness; it is a quality of things, manifest in a simple way in the snow-crystal and the precious stone, manifest in high degree in flowering plants and the masterpieces of the air.

In any case the fact is clear that it is intrinsic in

living creatures to be beautiful. This must form part of our world-picture. As Lotze said: "It is of high value to look upon beauty, not as a stranger in the world, not as a casual aspect afforded by some phenomena under accidental conditions, but as the fortunate revelation of that principle which permeates all reality with its living activity." The religious mind seeks to appreciate the deeper significance of Nature, and it must seek to do justice to the fact of beauty. It was for long a prevalent, though extraordinary, opinion that beauty was exceptional in Nature, something exotic like an Orchid, or rare like a Bird of Paradise; but men's eyes have been opened to see beauty crowding the common country places, and Saint Peter's house-top lesson has been widely learned. Perhaps the height of beauty is that of the spirit shining through the flesh—"her temple face was chiselled from within"; perhaps this is throughout the open secret.

Evolution

Another implication of life is its flux. The most constant thing is change. We are so short-lived that we hardly realise the extent to which organic evolution is going on in the world around us. No doubt, there are conservative types, which found a position of organic and environmental equilibrium ages and ages ago, and have remained much the same ever since; but this impression of stability has to be sup-

plemented by that of flux. The mere numerical fact that there are over twenty-five thousand named and known backboned animals and ten times as many backboneless animals, gives us an impression of the strength of the fountain of change. But it is not merely changefulness that impresses us; there is persistent advance. Throughout the ages life has been slowly creeping upwards. No doubt, there have been stocks, such as Sponges, that have not led on to anything else, but have persisted like great eddies in the stream, evolving within a relatively narrow radius into an exuberance of beautiful and intricate, if unprogressive, types. One cannot expect much advance in a class that shows no nerve-cells! No doubt, there have been highly evolved races, such as the Flying Dragons, or Pterodactyls, which disappeared from the stage without leaving any successors. There are not a few of these "lost races," which had their day and ceased to be. No doubt, again, there have been retrogressions in evolution, degeneracies, simplifications, de-differentiations. This falling back is illustrated by many parasites which show the nemesis of their life of ease, and other instances may be found among animals that have relapsed into a sedentary mode of life, as in the case of the sea-squirts, or Ascidians, which begin so well, as free-swimming Vertebrates, and relapse into sedentary nondescripts, having lost their supporting axis, their brain, their nerve-cord, and their eye. But after

full allowance is made for blind-alleys in evolution, for lost races without descendants, and for retrogressions, the big fact stands out clearly—that organic evolution has been on the whole integrative and progressive. It is not merely that the present is the child of the past and the parent of the future; there has been an advancement of life. For long ages, the highest living animals were Fishes, which had the seven seas for their kingdom. Ages passed and from a fish stock there emerged Amphibians, which began (among Vertebrates) the colonisation of the dry land. They made many important acquisitions, such as fingers and toes, true ventral lungs and nostril-breathing, a three-chambered heart, a mobile tongue, and a larynx with vocal cords. Ages passed and the highest living animals were Reptiles, a motley and variable crowd, completing the conquest of the solid earth which Amphibians began, yet often showing a tentative return to the waters when their haunts became overcrowded. Readaptation has often occurred in evolution, but there seems to be no reversibility; thus turtles, though readapted to the open sea, must return to the shore to deposit their eggs, one reason being that gills have been quite lost and that the young could not develop within eggs immersed in water. From a stock of extinct Dinosaur reptiles (the Ornithischia) Birds evolved, and from another (the Theromorpha) came Mammals. This is the broadest fact of organic

evolution—the gradual ascent of life—and it is eloquent.

As age has succeeded age, there has been an emergence of finer, freer, more masterful, more emancipated types. There has been a growing dominance of the mental aspect. It looks as if life became increasingly a satisfaction in itself. The general impression is what Lotze spoke of as "an onward advancing melody," and to the religious mind this should count for much. We live in an evolving cosmos.

The Religious Interpretation of Nature

The attempt to find a scientific basis for theism appears to us to be a mistake. We cannot by scientific searching find out God. Therefore we do not seek to rehabilitate the "cosmological argument"; there seems to us more wisdom in the remark of a distinguished physiologist, Doctor J. S. Haldane, that "the life of such a man as Charles Darwin is in truth a standing proof of the existence of God."

Our position is, that those who have attained in any degree to a Vision of God, along pathways not scientific, may find their vision clarified and widened by a study of Nature. When we try to think of the institution of the Order of Nature, and of the original endowment of the irreducibles with qualities which admit of progressive synthesis, we are at the end of our intellectual tether, and may find some satisfaction in a religious interpretation. When we think of

the persistent progressive urge manifested throughout evolution, and of the finer and finer emergences, each revealing some new richness in reality, our religious interpretation is confirmed and perhaps ennobled. When we think of what Science philosophically implies, reason answering to reason, we may be brought near the God of our fathers—also the God of evolution—whose name, JEHOVAH, meant not only, "I am what I am," but, "I will be what I will be."

SUMMARY

(1) Living creatures could not begin to be upon the earth until the surface became suitably cool. How did they arise? Some thinkers insist on the insolubility of the scientific problem of the origin of organisms upon the earth. They declare that the only possible solution is in transcendental terms. Others take up an agnostic scientific position, waiting till more facts are forthcoming. Helmholtz, Kelvin, and others have suggested that minute and simple forms of life may have been brought to the earth from elsewhere. The evolutionist suggestion is that living creatures may have arisen by some process of natural synthesis from non-living materials. There are difficulties in the way of this hypothesis, but there are some recent experiments that tell in its favour.

Very important are the researches of Professor Baly and his collaborators, which show that formaldehyde can be formed by the prolonged action of light on carbon dioxide and water, and that further synthesis can be effected by the addition of nitrites and the continuance of the illumination. Many difficulties remain. It is not easy to point to synthetic processes at present going on in Nature apart from life. It must also be remembered

that the problem is the origin not of a mixture of proteins and the like, but of organisms. While these and other difficulties must be frankly recognised, the general scientific verdict is in favour of the idea that there has been continuity of process from nebula to solar system, from cooling earth to awakening life, from primitive organisms to man.

(2) Our picture of the world must give a prominent place to the phenomenon of life, and we must inquire into the common features of living creatures. The key-words which sum up the criteria of a living organism, as contrasted with a not-living thing, are: Metabolism, Specificity, Persistence; Growth, Reproduction, Development; Behaviour, Enregistration, and Variability. The synthesis of these three groups of triads gives living creatures their uniqueness. In comparing organisms with machines—both are systems adapted for the transformation of energy—it must be borne in mind that machines do not exist in Nature. They are human collocations, embodying a rational idea. A living creature differs from a machine in being self-stoking, self-regulating, self-repairing, self-increasing, self-multiplying, and, eventually, in being self-conscious.

(3) But this statement of the criteria of livingness is too cold and analytic; we must envisage the world of organisms more warmly and synthetically. What are their characteristic qualities? First, there is the quality of victorious *insurgence:* organisms are multitudinous, ubiquitous, plastic, vigorous, defiant of difficulties, always attempting the next-to-impossible, triumphing over materials.

(4) A second impression is that of *intricacy*, both of structure and function. The nerve-cells in our cerebral cortex number more than five times the population of the earth, and every cell is a microcosm. Within each cell there is an orderly laboratory, in which there take place oxidations, reductions, hydrations, condensations, fermentations, up-buildings, down-breakings, all proceeding

at great speed, all very close together and yet not interfering with one another. We admire a complex machine and honour its inventor; why not extend our admiration more generously to the organism, and our honour reverently to its Creator?

(5) A third big impression is that living creatures are in varying degrees *effective agencies.* Effective self-preservative response is characteristic of life. Three errors must be avoided: (*a*) On the one hand, organisms are not creators of physical energy, only transformers; (*b*) but no complete vital phenomenon has been as yet described in terms of matter and motion. A new synthesis has emerged, that has made everything new. The physico-chemical formulæ do not suffice for the adequate description of vital activities. There is a chemistry and a physics of the living body, but when they are added together they do not amount to a biology; and they necessarily fail to grip mind. (*c*) It is not inconsistent with a recognition of spontaneity and effective agency to recognise also that it has been part of Nature's tactics to enregister and engrain, so that a certain obligatoriness or automatism results. There is often an obvious advantage in this when it gives the organism more freedom for experiment and new departure.

(6) A fourth feature is *adaptiveness.* Every organism is a bundle of fitnesses. Structures and functions are not only in a general way 'fit,' they are specially adjusted or adapted to particular needs and circumstances. It is no longer possible to argue directly from these fitnesses to either the skill or the benevolence of the "Divine Artificer," for the history of some of the thousand and one adaptations can be worked out in some detail. But a deeper teleology takes the place of Bridgewaterism when we recognise that organisms are such that they can adapt themselves age after age to novel needs and circumstances. The same structure may be radically adapted several different times in several different directions.

(7) Another characteristic of the realm of organisms is the tendency towards correlation, towards the inter-linking of lives. This is one of the central ideas of Darwinism—the idea of the web of life. There is a trend towards the establishment of a Systema Naturæ with subtle inter-relations. In envisaging the phenomenon of life, it is impossible not to give prominence to the fact of inter-relations. Nothing lives or dies to itself. Organisms are such that they work into one another's hands in mutual dependence and perfecting. This gives an interesting connectedness to Living Nature; it diminishes the fortuitous; it makes the system and history of Nature more like a consistent thought. The idea of the web of life is important in showing that small new departures may be sifted in very finely meshed sieves, which are themselves evolving as inter-relations multiply. Thus many variations in flowers will be winnowed in relation to the flower-visiting insects; and conversely, many variations in insects will be winnowed in relation to the favourite flowering-plants. Moreover, there is in the establishment of inter-relations a method of securing progressive steps. Just as in human affairs, so in Animate Nature, a step of progress which involves not only the individual constitution but an inter-linkage with other organisms has an increased likelihood of persistence. Since organisms do not live altogether to themselves, but also as retainers to other parts of Nature, there is a lessening of the risk of their slipping down the rungs of the steep ladder of evolution.

(8) With few exceptions, which prove the rule, living organisms have the quality of beauty. A case can be stated for the view that this has an objective basis, that it is an expression of orderly wholesome living, of a unified harmony of constitution from which the discordant has been sifted out. In the religious world-picture the fact of beauty must be appreciated as part of the revelation of the nature of things.

(9) Another implication of life is its changefulness. Living creatures are in a state of flux. No doubt, there are conservative types, but they are exceptional. The most constant fact is change. But there is more than kaleidoscopic variability, there has been an advancement of life. After due recognition has been given to non-progressive stocks, such as Sponges; to lost races with no descendants, such as Pterodactyls; and to retrogressive change, as illustrated by parasites and sedentary animals, the big fact is that organic evolution has been on the whole an integrative advance. As age has succeeded age, there has been an emergence of finer, more masterful, more emancipated forms of life. As Lotze said, there is an onward advancing melody. The biggest fact of all is the growing dominance of the mental aspect.

CHAPTER V

PSYCHOLOGY AND RELIGION

Problems to be Faced. The Gradual Emergence of the Psyche. Integration: Nervous, Hormonic, and Psychical. Man's Solidarity and Apartness. The Vindication of Personality. Materialism. Epiphenomenalism. Biologism. The Unconscious. Origin of Religion. The Correlates of Religion. The Culture of Personality.

Problems to be Faced

A SINGLE lecture on Psychology and Religion may well seem utterly preposterous, for how can any one in a short compass discuss the relations of a great science and the highest discipline of the spirit of man? On the other hand, a lecture may legitimately express a personal point of view, and that is all that is aimed at here.

Among the problems to be faced are the following: Since religion is a very personal activity, what has science to say in regard to Man's personality? With what other strands in our personality is religious activity particularly correlated? Does religious experience admit of psychological analysis, and, if so, how does that analysis affect the validity of religion?

The Gradual Emergence of the Psyche

What has science to say in regard to Man's personality? Part of the answer must be that Organic

Evolution has been marked by a gradual emergence of the Psyche.

One must notice, to start with, that the behaviour of living creatures in their effective answering back is often such that our scientific descriptions of it do not require the use of psychological concepts. The nervous system suffices. We do not require a mind in order to cough or sneeze, though a mind may perhaps be of service in inhibiting these reflexes. Given an established chain of three kinds of nerve-cells: scout-cells, or sensory neurons; G. H. Q. cells, or adjustor neurons; and executive-officer cells, or motor neurons; and given the common soldiers, or muscles, we can describe what occurs, leaving the mind out. We do not need to recognise the mental factor in giving an account of what happens when we shut our eye before an approaching missile.

In considering reflexes we may leave the mind out, but three saving-clauses should be noted. First, there may be associated mental activity which does not function as a factor. Secondly, from time to time, the psychical side may intervene and control a reflex. Thirdly, it is possible that the psychical activity of the animal may have been operative in the historical evolution of the reflex concatenation, for instance, in testing and profiting by a new neuro-muscular complexity.

When we pass from the humbler animals to the higher, or when we take account of the upper reaches

of an animal's life, even when it does not stand very high on the scale of being, we cannot overlook the reality of an agency that is more than neural. The animal makes an inference, it appreciates a situation, it adjusts means to ends, it remembers, imagines, and even purposes. Mind has emerged; from being a flickering flame, it has become a fire. We cannot make sense of the animal's behaviour without postulating the efficiency of Mind. There are some extreme behaviourists who have persuaded themselves that mind does not operate as an efficient factor in even complicated animal behaviour. Constructive criticism on the other side may be found conveniently in Professor MacDougall's *Outline of Psychology* (1923).

Let us take a low-level instance. A Queensland spider, called the Magnificent, lowers herself by a silken rope and spins a thread about an inch and a half in length, which bears at its end a viscid globule about the size of a pin's head. When a small moth comes fluttering past, the spider catches it by whirling out the viscid globule with great velocity. When the moth is touched by the viscid globule, it is as helpless as a fly on a fly-paper. It is drawn towards the spider as a fish to the angler, and then sucked. In South Africa there is another, distantly related, spider which shows a similar device, but it keeps its viscid droplet whirling round and round for a quarter of an hour at a time. It then changes it, for the bait

has become dry. We suppose a thousand-and-one similar stories might be told, and frankly we cannot make sense of them if mind is negligible. The spider has no science of ballistics; it does not individually invent what it does; but an apsychic account appears to us like the play of "Hamlet" with the part of the Prince of Denmark left out.

Let us take a high-level instance. A young Gorilla, trained by Miss Cunningham in London, became cleanly, well-mannered, orderly, deft with tools, affectionate, sensitive to rebuke, and more besides. It was very young and craved for companionship; it played gently with a child. One day when Miss Cunningham was going out and happened to have put on a light dress, John Gorilla begged to be taken on to her lap before she left. Although he was clean and tidy, he was sometimes dusty, being of an exploratory turn of mind, and Miss Cunningham's sister warned her not to grant the child-gorilla his wish. He was refused, whereupon he threw himself on the floor and sobbed like a petted child. As no heed was paid to him he soon got up, and looking about the room found the daily paper, which he brought to Miss Cunningham and spread over her lap. No doubt, one requires to know more about this story and one must not be hastily overgenerous. But there are several similar cases, well-documented, and it appears to us to be impossible to describe them without recognising judgment as an efficient cause.

It would be easy to give a score of good examples of behaviour at low and high levels which it seems impossible to describe without recognising that an imponderable non-material factor counts. Allowing for the continual tendency to enregister and engrain, so that a piece of behaviour, frequently recurrent, ceases to require attention or control, there is, we maintain, an immense stretch involving mental agency.

Or again, if we look backwards on the advance of animal life through the ages, the large evolutionary fact is that the mental aspect becomes more and more prominent. It may be that the amœba has only flashes of mind, while in a dog there is a steady glow. Obviously there is no linear order of advance, and the little-brain type, seen at its best in ants, bees, and wasps, seems on a side-track, on a predominantly instinctive, not on a predominantly intelligent, line of evolution. Yet even here mind counts. Many careful investigators would agree that instinctive behaviour, which is like a chain of reflex actions in its physiological aspect, is likewise suffused with awareness and backed by endeavour.

No one has more right than Professor W. M. Wheeler to make a pronouncement on the behaviour of social insects, such as wasps; and what does he say? "We observe in wasps a high degree of modifiability of behaviour and an extraordinary development of memory, endowments which have led Mac-

Dougall to claim for them 'a degree of intelligence which (with the doubtful exception of the higher mammals) approaches most nearly to the human,' and Bergson to point to their activities as one of the most telling arguments in favour of his intuitional theory of instinct. Although I believe that these and many other authors have been guilty of some exaggeration, the wasp's psychic powers compared with those of most other insects or even of many of the lower Vertebrates seem to me, nevertheless, to be sufficiently remarkable." (*Social Life Among the Insects*, 1923, p. 45). This is an important statement on the part of a very acute thinker as well as a careful observer.. *Mind counts.*

If the reality of the psychical aspect of life and its evolving explicitness be admitted among the children of instinct, the same is true *a fortiori* for the main line of evolution with its big-brain types. For millions of years the Vertebrate brain remained more of a promise than a fulfilment. Of most fishes, amphibians, and reptiles, it must be allowed that they are no cleverer than they need to be. The brain is primarily an organisation for superintending the doing of things, only secondarily for thinking about them. In the lower reaches of the Vertebrates we see much in the way of forming associations and remembering them; it is not till we come to birds and mammals that we discern a rich efflorescence of intelligence and emotion. Sometimes we get a glimpse of an animal,

such as dog or horse, guiding its behaviour by what seems to the outsider like a perceived purpose. All that we are concerned with here is an appreciation of the big fact of mental evolution. As age succeeded age the leading types of animal life along various lines of evolution advanced in bodily differentiation and integration, in mastery of their environment and complexity of inter-relations, in freedom and fullness of life. But there was something more; there was a movement towards the emancipation of the Psyche. There was more feeling and more understanding in the life of the creature. The world means more to the mavis than to the earthworm, and the mavis is more of a free agent. Its life must be more of a satisfaction in itself. Here is a big fact, admitting of religious interpretation, the evolutionary trend towards the increased dominance and freedom of mind.

> "And, striving to be man, the worm
> Mounts through all the spires of form."

Integration: Nervous, Hormonic, and Psychical

A survey of the increasing emergence of mind in the course of Organic Evolution discloses, we think, something more than we have indicated. Above all else evolution is *integrative;* its expressions become more and more subtly unified. There is integration by means of the nervous system, so that the centres are ever receiving tidings from the outskirts, and these are ever thrilling to the spur and bridle of the

brain. More and more does the whole body come under the sway of the higher centres with their associative, or adjustor, nerve-cells. There is also integration by means of the blood, the common medium from which all the cells of the body take and to which they all give; and the importance of this integration has been more appreciated in the present century by a recognition of the rôle of the regulative chemical messengers, or hormones, which are produced by the ductless, or endocrinal, glands and distributed by the blood throughout the body. More and more we recognise the insight of Saint Paul's biology:

"Yes, God has tempered the body together, with a special dignity for the inferior parts, so that there may be no disunion in the body, but that the various members should have a common concern for one another. Thus, if one member suffers, all the members share its suffering; if one member is honoured, all the members share its honour."

But there is a third kind of integration, and that is psychical—a growing unification of consciousness. We cannot indeed dissociate it from the integration of the nervous system, yet it is different. It is the evolution of the self—such as we are familiar with in the individual development of man. From infancy to childhood, and on to coming of age and after, the human personality develops; the idea we wish to suggest is the evolution of personality at levels below man. Or, if we keep the word personality for man, as

seems best, let us at least recognise that in highly evolved types like dogs and horses, rooks and parrots, there is an individuality in process of evolution, a unifying of consciousness. We can see it when an animal, dominated by a perceived purpose, such as capturing booty, or winning a mate, or protecting its offspring, has every bow in its body bent in the same direction. It may be noted here that the emergence of individuality (or animal personality) is aided by social relations, and that sojourning with and co-operating with man has a strong influence in the direction of liberation, as we see so clearly in the case of dogs and horses.

Man's Solidarity and Apartness

The biologist is apt to think much of Man's solidarity with the rest of creation, and too little of his apartness. To the religious mind, on the other hand, the apartness of man is the big fact, and his affiliation is negligible. But the crown of Nature may also be the child of God. Keeping on our scientific spectacles, let us ask for a moment wherein Man's apartness consists.

The fundamental biological fact is the advance in the cerebral cortex, probably as the outcome of a mutation, but having some correlation with the erect attitude. This big brain is the physiological correlate of man's high capacity for intelligence, for language, and for experimenting with general ideas

(conceptual inference), of which words are the usual counters. Many animals have words, but there is never more than an adumbration of language. Many animals have intelligence, but only man has reason in the strict sense. Many animals are kindly, self-subordinating, and social, but we can hardly call them moral agents. Man, with his very strong social sympathies, has evolved ethical ideals, in reference to which he sometimes controls his conduct. He is swayed by the urges of hunger and love, and by various inborn or instinctive predispositions, but he often summons their promptings before the tribunal of his higher self—his conceived purposes. He approximates towards a unified consciousness, and he has formed the habit of looking at himself in the mirror of his mind. Furthermore, what is hinted at in social animals becomes in mankind an extraordinarily powerful factor—the social heritage, or, from another point of view, the social environment, in which the gains and lessons of the past are enregistered outside the organism and independent of any germ-plasm. It forms a vast system which sifts for better and for worse the new departures that are always cropping up; it is a means of guaranteeing continuity of movement—*sometimes* progressive—and of preventing the individual from slipping down the rungs of the steep ladder of evolution. There has been an evolution of sieves as well as an evolution of materials to be sifted.

But what has this to do with our subject? The answer is that religion is pre-eminently a response and discipline of the personality, and it is, therefore, of great moment to know that a strong trend of evolution is behind us, in so far as the historic process has persistently worked towards integration of life and mind. If we think of the process of evolution as the unfolding of a Divine Thought, the expression of a Divine Purpose, it is of more than passing interest to find that from the beginning to the present—which we cannot think of as the end—there has been a consistent advance towards personality. In this great fact there is a suggestion of a promise: it may be that in the religious life, which is the highest discipline of personality, there is evolving a new psychical liberation.

The Vindication of Personality

What results from our survey is an impressionist picture of organic evolution as integrative and as psychically integrative. The organism is a new synthesis as compared with a crystal; the thinking, feeling, willing organism is a higher synthesis still. Organic evolution makes for a fuller emancipation of the Psyche. In animals we see the beginnings of Personality.

Religion is essentially an appeal of man's personality to the Divine; it means sending out tendrils into the Absolute. As has often been said, Religion

is between myself and God. But as we are afraid of illusions, we welcome anything that Science can do in vindicating the reality of the self. But, as a matter of fact, in the present age, science tends to work in the opposite direction. We are in the midst of an analytic period, in which the sense of Personality is often shaken.

Man's sense of personality—a postulate of all philosophy and all religion—is a primary certainty of his experience, and we have no hope of replacing that conviction by scientific arguments. What we wish to do is to consider in a non-technical way some of the assaults that the sense of personality has to withstand in modern times.

Materialism

The first axe is MATERIALISM, in regard to which a little has been already said. The materialistic outlook sees only electrons and protons, and such energies as gravitation. It leaves mind out of account, regarding it as an illusion produced by living matter. There are neuroses of brain-cells, and the echo is called 'Mind.'

To this it may be answered that "Matter" is a mental abstraction. "Matter," consisting of electrons and protons, both as ethereal as they make them, is an aspect of reality that we envisage by following certain methods of observation and experiment. We cannot catch "Mind" in a net whose

meshes we have previously adjusted so as to catch nothing but "Matter." It is only word-jugglery to say that "Matter" produces "Mind," for we have already used our mind to make our matter. An integrated galaxy of electrons and protons cannot make the theory that there is no mind; for making the theory is mind. To put it in another way: Matter and Mind are incommensurables.

More positively it may be urged that there is much in the world—in the realm of organisms as well as in the kingdom of man—which cannot be described in terms of matter and motion. The chemico-physical categories are insufficient. In animal behaviour and in evolution there are indubitable aspects of reality which transcend the laws of chemistry and physics.

Epiphenomenalism

A sharper axe is EPIPHENOMENALISM, which regards "mind" as the mere byplay of cerebral processes; the foam-bells on the stream; the whirr of the wheels. The answer is that "mind" *counts.* Ideas, as Hegel said, have hands and feet. The most powerful factor in our life is our imponderable purpose. We cannot make sense of animal behaviour unless the psychical life 'counts.'

As long as it is agreed that the psychical life is an efficient cause, we need not include among the axes that threaten personality the difficulty involved in

thinking clearly about the body-and-mind relation. That the life of the mind and the life of the body are in intimate correlation is an every-day fact of experience, corroborated by many different kinds of experiments. But beyond that who has any scientific certainty?

When all is said, and a great deal has been said, the alternatives are but two—dualistic and monistic—and both are bristling with difficulties. It looks as if this body-and-mind relation were one of the limiting problems of human intelligence; it looks as if we were not yet able to ask the question rightly. When we find two men as competent, wise, and good as Professor Lloyd Morgan and Professor W. MacDougall on opposite sides, we realise how difficult the problem must be. On the dualistic view, the mind is to the body as the musician to his instrument; the musician needs his instrument, but he can live without it; he is limited by it, and yet he transcends it. On the monistic view, the life of the organism is one, but has two aspects, objective and subjective, like the convex and concave surfaces of a dome. In certain activities, such as digestion, the protoplasmic side is dominant; a mind-*Body* is active; there is psycho-biosis. For everyone knows that good news helps digestion. In certain other activities, such as meditation, the psychical side is dominant; a body-*Mind* is active; there is bio-psychosis. Nevertheless a poor digestion often goes with pessimistic philosophy.

To most religious men, the dualistic view seems most congruent with their other convictions; but Spinoza, one of the greatest of Monists, was intensely religious. The 'body' is an integration, often with a highly developed correlate of 'mind'; the 'mind' is an integration, usually with a highly developed correlate of 'body'; both are evolving. May it be that in Man *another* integration is in process of evolution—a reasonable Soul?

But whether we believe that the psychical musician plays on the material violin of the body and brain; or that the musician and the violin are two aspects of the same reality—the organism; the more important thing is that there should be music; and the maker of the finer music is the Personality which monists appreciate no less than the dualists.

Biologism

The third axe is BIOLOGISM, a false simplicity at a higher level than materialism. It expresses itself in a depreciation of the apartness of man. It overemphasises man's solidarity with mammals; it makes too little of the distinctively human—the power of conceptual inference or reason, the capacity for rational discourse, the ability to see oneself in the clear mirror of self-consciousness, the highly evolved kin-sympathy, the incipient moral life.

Another aspect of biologism is seen in the exaggeration of the rôle of the ductless glands, whose secre-

tions are distributed by the blood throughout the body. It has been one of the great discoveries of the twentieth century that the bodily life is regulated by a system of ductless or endocrine glands, such as the thyroid, the suprarenal, the pituitary body, and so forth. They have subtle regulative functions which promote harmonious life by means of potent chemical messengers which are carried by the blood to all the holes and corners of the body. There are hormones that excite and chalones that quiet down. They are drifted about like floating keys, seeking closed locks which they should open, and open locks which they proceed to close. If a child suffers from thyroid deficiency it remains arrested in development both bodily and mental—a cretinoid caricature of humanity. By the use of thyroid extract or even by eating the thyroid gland of some mammal, like a sheep, the handicap of natural deficiency can be in some measure removed. This is one of the miracles of modern medicine. Now it is certain that a change in the normal efficiency of these regulatory glands may change the whole tenor of a life, altering mind and mood, character and conduct, as well as the state of health. The possibility of things going agley is the tax we have to pay on having a really wonderful regulatory system, just as death is the tax on a body worth having.

It is also certain that a notable innate aberration in the activity of one or other of the regulatory

glands may affect the whole development. As Sir Arthur Keith has suggested, it may even be that some of the differences between races came in the wake of variations in the activity of the ductless glands. Everyone will agree that the discoveries in connection with the ductless glands have been of great practical importance, but they have carried some thinkers off their feet. Thus it has been said that the ductless glands *determine the personality.*

This seems to us to be an exaggeration, a biologism. The diversities in the personalities are much wider than the known diversities in the endocrine glands. In most cases the inheritance includes relative normality of the regulatory system. The ductless glands correspond to accelerators and brakes, and no one can doubt their importance; but there are not less important parts of the inheritance—the nimble brain, the strong heart, the active liver, not to speak of controlling power and good-will. Moreover, the personality is made as well as born, and it is for a man to adjust himself to the deficiencies and exaggerations of his ductless glands. Beyond a certain limit, he must "drie his weird"; up to that limit he is master of his fate and captain of his soul.

The Unconscious

The fourth axe that has been used against man's conviction of an integrated self or personality is the modern theory of the unconscious. We cannot under-

stand our daily life without recognising that there are powerful factors which are not in the focus of consciousness. When we think of the stream of our life we recognise a surface-play of sensations and feelings, of percepts and concepts. This is more or less under control—everyone experiments with ideas—and it is mostly in the daylight, so to speak. In a happy life much of it is sunlit. But it is equally certain that much of our life is below the surface. Near the bed of the stream there are racial tendencies, fundamental urges and appetites, old-fashioned predispositions. Some of these have a force that may be disturbing, causing eddies on the surface, but others are like springs of sweet water rising in the stream. Many people talk so much about Original Sin that they ignore the reality of Original Righteousness—the light that lightens every man that cometh into the world. Most of us have good reason to be afraid of Original Sin; all of us have reason to be grateful for Original Righteousness.

Deep below the surface are sunken memories, some of them relating to experiences that never passed through the focus of consciousness at all. Of great importance are early impressions, the enregistered smiles and tears of childhood. What Walt Whitman said of the child who goes forth every day is profoundly true, both for good and ill; what he sees becomes part of him for a day or for a year, or for stretching cycles of years. All these deep under-

currents constitute what may be called *the primary unconscious.*

Different from this, however, is the secondary or Freudian Unconscious, which consists of down-sunk groups of disharmonious ideas invested with emotion. They are incompatible, painful, disturbing "complexes," which try to escape from their prison. They often emerge in dreams, and sometimes we hardly know ourselves when these ghosts occupy the nocturnal stage. These groups or complexes of ideas, with their associated emotions, have sunk out of the light—an automatic result of their old attempts to find expression. For their sinking down into the depths is rather an unwitting repression than a deliberate suppression. They came into conflict with the repressive forces of social conventions, ethical standards, and religious ideals; they slink away from the light; they resemble "negatively heliotropic" organisms. They are not skeletons in the cupboard, for they are powerful and very much alive. They are sometimes like Titans, moving the repressive rocks that have been piled on them. He must be very easy-going or very happy who is not troubled by his Freudian Unconscious.

All this, we think, and much more, must be admitted; but there seems considerable risk of exaggerating the Freudian Unconscious into a bogie. Doctor W. L. Northridge writes in his well-balanced book, *Modern Theories of the Unconscious* (1924, p. 177):

"Psychoanalysis indeed has gone a long way towards robbing consciousness of all its value and power, and attributing most of our behaviour entirely to the unconscious. Consciousness is conceived as the slave of the unconscious—the latter being all-powerful." Or, the supposed fact is put tersely: "The ego is no longer master in its own house." This seems to us a monstrous exaggeration, and we venture to submit the following considerations:

(1) The Secondary, or Freudian, Unconscious, like the Primary Unconscious, may be thought of as occupying a certain area in our constitution, a certain level in our life-stream, but the warrant for hypostatising an unconscious Self is very unconvincing. So is the idea of a "Censor," a rather ridiculous fiction, who watches the prison doors but sometimes falls asleep. The Unconscious Self is spoken of as a low-down, cunning, not very respectable fellow, who tries to trick the "censor," for instance, by attaching a forbidden idea to one that has right of exit. The facts are serious, and many great thinkers, like Saint Paul, have found themselves forced into the recognition of something like a double self; but it does not follow that this dualism is warranted, or that it need go the length of declaring the Conscious Self to be the slave of the Unconscious Self. There seems to be no need to multiply selves or consciousness, except as a verbal device in analysis.

Is there not great wisdom in what Saint Augustine

said (*Confessions:* VIII., chapter 5): "The new will which I began to have was not yet strong enough to overcome that other will strengthened by overindulgence. So these two wills, one old, one new; one carnal, the other spiritual, contended with each other and disturbed my soul. I understood by my own experience what I had read, "flesh lusteth against spirit, and spirit against flesh." It was myself indeed in both the wills, yet more myself in that which I approved in myself than in that which I disapproved in myself." It will be understood that in recoiling from the concept of an Unconscious *Self*, we are not denying the reality of abnormal dissociations, such as those technically referred to as "Multiple Personality."

(2) Everyone admits that important curative results have been obtained by the use of psychoanalytic and psycho-therapeutic methods in the hands of well-qualified experts, who are able, for instance, to induce the patient to unearth or unravel his 'complex' and look it in the face. In various ways he may be led to understand himself better, to take a more objective view of his condition. Various modes of treatment may follow, such as suggestion, reassociation, recentring of the personality, encouragement, the awakening of new interests, and trying "the expulsive power of a new affection." We are not concerned with any details here, but this general fact should be borne in mind that it is the prerogative

of a normally constituted man to be continually summoning his motives before the tribunal of his higher self—his reason, his ideals, his life-purpose. This is the normal ethical discipline, obedience to which may save many from the thraldom of the Unconscious. It seems to be true that unconscious motives bulk largely in our behaviour, but men and women whose experiences are not extraordinary can certainly do much to keep the stream of their life flowing—without the formation of very serious repressive *eddies*.

It should also be kept in mind that the personality is not stationary. It is a developing integration, always fashioning itself afresh. It is appealed to by many influences—by urges and appetites, by predispositions and memories, by habituations and by ideals, and by unconscious motives among the rest; but it is a living, growing integration and it does not always respond in the same way. It sometimes learns to love the light.

(3) It is important to recognise that it has been part of the process of human evolution to sink particular anachronistic impulses into the Unconscious. There is a normal sinking down of the impulses to, let us say, murder or violent lust. Apart from the individual's deliberate suppression and automatic repression there has been a slow but sure racial change, effected by the persistent relative elimination of the more "impossible" variants and the

persistent relative success of the more humane and social types. The Unconscious includes a system of hereditary inhibitions which help us to draw back from evil and a system of hereditary promptings which help us towards what is good; and these are very different from Freudian "complexes."

It may be said on the other hand that our discourse betrays a prejudice against the modern theory of the dominant power of the Freudian Unconscious Self, and that this is another of that Self's familiar tricks. Perhaps it is enough to say that we are vividly conscious of this danger.

Origin of Religion

We have seen, then, that in modern times various axes have been used to hew at the posts of the temple of the spirit. The materialists have pretended that the only realities are matter and motion. The epiphenomenalists have maintained that mind is a by-product that does not count. The extreme biologists have depreciated Man's apartness from mammals or have exaggerated the dominance of the ductless glands. Some of the modern psychologists have exaggerated the rôle of the Unconscious, especially the Freudian Unconscious. They have likened the personality (somewhat coldly and passively) to an iceberg, the submerged part being the larger and the more important.

The use of these axes does not necessarily mean

hostility to religious activity; it expresses in most cases a fear of illusions, a desire to face the facts however bleak, and a strange belief that scientific method is the only right-of-way to truth.

If the metaphor does not become too wearisome, we may perhaps say that a fifth axe has been found in the study of the origin and history of religions.

There seems to be little warrant for supposing that early man was endowed with an innate tendency to build up a religious creed or ritual. Early man was a seeker after life rather than a seeker after God. He found himself encircled by death, which he feared, by forces of Nature which he could neither understand nor control; he had his emotional crises when he was exalted above himself or sunk into the depths of despair. He stretched forth his hands—thinking and feeling, as well as doing, hands—and clutched at straws. Often, it may be, one of his fellows with more insight suggested some procedure, some idea, that might be of use. Having done all he could, he seized the clew of hope.

Let us think of concrete experiences, for it was out of these that man built his ladder to the skies. Death robbed him of his beloved child; death was a loss of blood; the cold body was surrounded with red earth, symbolising blood; the straw that man clutched at was the hope of the beloved living on or returning; the colour of the straw, so to speak, was red. Besides death, the other great mystery is birth; the

portal of birth was regarded as "a giver of life," and the use of the cowry shell, as the symbol of life-giving, spread from the Red Sea round the world. It might be that two cowries were laid on the forehead of the dead, as well as on the hands and feet, to try to make sure that the living-on would be mental as well as bodily. It might be that a cowry necklace was worn by the women that they might have children and help in their time of need. By and by other shells became givers of life. And one cannot but believe that the beauty of the shells was in some way appreciated.

The huntsman who had been terribly torn by a beast of prey sought to ensure himself and his sons from future risks of the same kind. The tradition was to wear a necklace of the teeth and claws. If these protect their original animal possessors, perhaps they will protect us. Perhaps the lion will not kill us who wear his claws. It may also be noticed rationalistically that when the necklace was collected by the wearer himself from wild beasts his safety would increase with his success.

So far, then, it may be said, early man practised magic, rather than religion, and magic is a word of bad odour. Perhaps, however, it was, for some races at least, the necessary young form of religion. For what leads man to magic, but reaching the limit of his practical, emotional, and intellectual tether? And it is the same experience of having done all and

failed that led man to religion, and leads him there still. Picture early man desperate, ringed round by fear; or beside himself with anxiety or grief (and sometimes joy); or puzzled oppressively by the mysteries of life and death and the big booming world of Nature. He clutched at straws; his descendants are doing so still. This is the threshold of religion.

We cannot say, Lo here, Lo there, but perhaps the religious note was first clearly struck, as Professor Elliot Smith suggests, when men imagined the Great Mother. There was a primitive apotheosis of maternity, not perhaps from the intellectual side, so much as from the practical and the emotional. It is to the mother the children go for consolation and help, even for protection in the day of the father's wrath.

The facts which research is making clear point to the primitiveness of the conception of a Great Mother, a life-giving, food-giving, protective, consoling mother. At a later period in Egypt the first god emerges in the person of Osiris, regarded as a former King, who ruled over the Kingdom of the dead, and gave them habitation. Later on, the Egyptians reached the conception of a kingdom in the skies, the realm of a great being, glorious as the sun, who ruled over the living as Osiris over the dead. But all was a transmundane projection of mundane experience.

Fear a Root?—To the evolutionist, accustomed to

think of birds emerging from reptiles and many similar transformations, there seems nothing improbable in the idea that, as Lucretius said, fear was often at the basis of worship. But, as we wish to be quite fair in our survey, we must notice that some specialists on the subject are very far from acquiescing in this view. Thus Professor Hugh R. Mackintosh (*Some Aspects of Christian Belief*, 1923, p. 204) writes forcefully as follows: "Everybody knows that in recent works on religious origins, especially those emanating from the anthropological school, it is frequently argued that men took to religion from fear; they thought everything about them had a soul and, therefore, had to be appeased and made terms with, and religion is the name for political dealings with all such dangerous or uncanny objects. If this theory were true, it would be all over with religion as a permanent aspect of the best human life, and it is Theology's business, accordingly, to show that it is not true, or is at least a very small part of the truth. It has to bring out the fact that religion is not and never really was a pseudo-science of this kind, but has invariably risen beyond a merely animistic view of surrounding objects to a Power or Powers superior alike to the individual and to the world in which he lives—to an order of destiny, in short, with which man must find reconciliation."

It may be agreed that religion was never a pseudo-science, whatever that means, but the evidence that

fear was one of the springs of some religious activities is very strong, and we cannot understand why this fact should affect the value or permanence of religion in human life. Values are not affected by historical origins; and evolution is a continual re-creation.

The early fear—a fear of the forces of Nature—has been replaced by other fears in the course of ages, and many of us have still reason for being afraid.

The biologist has obviously no authority whatever in speaking of the origin and history of religion, but he is more accustomed than most people to the concepts of development and evolution. And one certainty that is firm in his mind is this, that the dignity of emergence is not affected by its genesis. The genius was once a little child, and lay implicit in a pinhead egg-cell. The philosophisings of the sage are in continuity with, though more than continuations of, the early efforts of the child to see things clearly. And, as with individual development, so with racial evolution; these early clutchings at straws are like the appeals of children—with no language but a cry. In the individual development we know the importance of the social heritage and the influence of a teacher; so in the history of religion we recognise as great factors the religious tradition and its embodiments, the rôle of the prophets who have always led the people, and the lives of the saints who have never been absent as exemplars. We are mak-

ing no statement in regard to the difference between natural theology and revealed theology—we are not competent—but surely it is safe to say that there can be no antithesis.

Modern science with all its splendour—weighing the stars and measuring the atom, annihilating distance and seeing the invisible—has it not grown out of ages of groping and fumbling? But the modern concepts of science are not the lineal descendants of the old half-superstitious lore. There is no piecemeal evolution. The human organism evolves, and so does the kingdom of Man, which includes not only the social environment but the natural environment in process of being mastered. The devising of new formulations is not the result of fostering and stimulating and rehabilitating old ideas, the new laws are fresh expressions of evolving mankind. So with religious concepts and disciplines; they are fresh expressions of the developing human spirit, of the evolving consciousness of mankind—social as well as individual.

The General Theorem Restated.—Let us state the case again. If religious feeling evolved in the course of man's history, it must have emerged from definite antecedents. It is the view of some that its origin is to be found in the deep-seated self-preservative desire for life; others refer it to a sublimation of the emotions centred in "love"; and there are other views. Thus it has been said that a unified sense of

the power in the world—the power exhibited in the heavenly bodies, the power in living creatures, and the power in our own promptings, needs, and ideals, fused with a sublimated sex-emotion, yields religious feeling.

Our position is that out of a personality which represents an integration of the whole nature, including all the strands of self-preservation, sociality, love, and sense of power, all the strain-results of coming to the tether's end, all the dim and clear reflections on history and experience, all the thrill of the beauty of Nature, and more besides, there has emerged a specific set of tendrils which we call religious, specific in their mystical appeal to some reality beyond the ordinary range of sense-experience. The evolution of the new appeals has been greatly assisted, as usual, by the external registrations in rite and ceremony, institution and tradition, so that there is not more than a predisposition in the individual man. Starting with a generalised rudiment or predisposition which may, sometimes at least, form part of the racial inheritance, and greatly influenced by the historical religion of his people, every man has to work out his own religion—which is an expression of his whole personality, a total reaction of his integrated self. What we are reiterating is not detailed criticism of this or that theory of the origin of religion, but the general notion, which most books on the subject appear to overlook, that the evolution of

religion depends in the main not on piecemeal additions or embellishments, not on particular prunings and mouldings, but on the evolution of human personality as a whole.

A Man-Made Affair?—It may be urged, however, that on this naturalistic view of the origin and growth of religion, it is all a man-made affair. One is tempted to answer: So are many other great and noble things. If the supernatural origin of the Bible and of Christianity be insisted on, one cannot, indeed, say that *all* forms of literature, philosophy, art, and music are man-made, for the Bible and Christianity have had a penetrating and pervasive influence on many of these. But there is much philosophy, literature, and art—in the East, for instance—which, without any argument, may be called man-made. And all science is man-made. Therefore, if we waive the question of a radical differentia between natural and revealed religion, we have reason to suspect that there is some deep misunderstanding in the question: Is religion man-made?

We have referred to the fears of primitive man and to his early clutching at anything that he hoped would be life-giving. We have advanced the general thesis that religious activity in its many forms always arose when man strained at the end of his tether—practical, emotional, or intellectual. Let us suppose, for the sake of argument, that this is a mistaken way of looking at the subject, it makes no difference

to the general proposition that the history of a resultant does not affect its value. A flower is not less a flower because it consists of four whorls of transformed leaves. Religion is such a flower. We are quite unable to follow the distinguished theologian who has said that, "if religion grew out of fear, it is all over with religion"; but we would refer the student to a more robust position defended in Professor Moore's Morse Lectures.

The Correlates of Religion

Every one who gives attention to the æsthetic emotion will soon become convinced that it is *specific.* It is itself and no other; thus it admits of no satiety, it is not decreased when others share, it is always excited by a particular here and now of beauty, and so on. But it does not affect the specificity of the æsthetic emotion to find that it is rarely pure—it is mingled with associations and memories; it is very often suffused with ideas. Nor is the idea of the specificity of the æsthetic emotion affected by the fact that it has had an evolution, of which we know very little.

The same may be said in regard to religion—it is specific, though seldom pure; it is specific though it has had a lineage. Of course religious activity may be practical and intellectual as well as emotional, but if we keep in the meantime to the emotional aspect, our suggested comparison with the æsthetic

emotion may help to show the fallacy of those exaggerations which psychologise religion as wrapped up with the so-called herd-instinct or with the so-called sex-instinct. These are associated strings in the harp of life, but they are different.

Religious activity is, we believe, essentially personal, "myself and God"; but a religious sentiment may pervade a whole society, a religious rite may be shared in by all the people, an article of faith may bind a race like the bond of blood. The social aspect of religion is familiar, and its suggestibility is a well-known source at once of strength and danger. But something more precise is meant by linking religion to the so-called herd-instinct, which we personally prefer to call the social predisposition. Man is organically gregarious, afraid of lonely places—for soul as well as body. Spiritually agoraphobic, he seeks his fellows. Raising this to the *n*th power, man reaches out religiously, according to Doctor Trotter, stretching his hands to a larger existence than his own, to an encompassing God. "Thou hast beset me behind and before." There seems no reason why there may not be a herd-instinct strand in religion, but to make the herd-instinct the tap-root of religion seems to us to show a lack of perspective. The social predisposition is a correlate, not an origin.

Similarly, the theory that religious feeling is a sublimation of love, to put it as finely as possible,

seems to us to contain a thread of truth, but one which may be very easily exaggerated into fallacy. Love, with its physiological roots in the sex-urge, has flowers like stars, and human life has nothing finer. But, except in deviations from the normal, religious activity is much less "sexual" than it is "social." The harp-string of love is correlated with that of religion and may vibrate with it, but religious feeling cannot be psychologised away by trying to interpret it as love *in excelsis*.

Sex and Religion.—It is admitted that the sex-urge with its flowers of love has been of fundamental importance in the evolution of human personality and remains a powerful factor in individual development; it contributes to the making of the self from which religious tendrils grow. But this is a different proposition from that which maintains that religious activity is directly evolved from love.

The flowers of love and their physiological roots are peculiarly central to the whole organism. Love is a reaction of the whole being, and the psychological integration is as marked as that which is physiologically effected by sex-hormones. Normally there is a unifying of the whole being; there is a total reaction of the personality. It is natural, therefore, that love should be in a peculiar way correlated with religious feeling. It is intelligible also that in abnormal cases the correlate should become more prominent than the primary activity. But this is a very

different position from that which denies the specificity of religious feeling.

Activities and expressions which have to be more or less deliberately suppressed, or which have undergone automatic repression, may form disturbing whirlpools. But, as Doctor R. H. Thouless puts it in his masterly *Introduction to the Psychology of Religion* (1923, p. 110): "One of the practical problems of religion is to provide an effective means of sublimation, so that the process of repression (which is liable to produce mental disorder) may be avoided." But this sound notion of diverting the sexual to the social is a very different proposition from that exaggeration which seeks to trace back all religious activity to sex-feelings.

It is plain that we cannot in a few sentences attempt a methodical criticism of theories to which eminent authorities have devoted many years and many pages, but we venture to submit the following considerations:

We have shown elsewhere (*What is Man?* 1923) that the word "instinct" is more confusing than useful when applied to the self-preservative impulse, the social predisposition, and the sex-urge. But let us leave aside this question of precision. It is maintained by erudite scholars and acute thinkers that religion has evolved from the self-preservative instinct, or from the herd-instinct, or from the sex-instinct. But is it not the case that religious activity

in its manifold forms—practical, intellectual, and emotional—has always a mystical element, something specific? There is a new note which is not sounded in the self-preservative instinct, or in the herd-instinct, or in the sex-instinct, or in all the three together. Religion came later, a new emergence, correlated, as we have admitted, with self-preservation, sociality, and love, and with other strings in the harp of life, but not evolved from any one of them or from all of them. The piecemeal view of evolution is erroneous. The organism evolves, and in man's case there is the not less important evolution of external registrations; and from the evolving organism religious activity *emerges*—itself and no other. Out of three sounds, as Browning says, there is framed, 'not a fourth sound but a star.'

Straining at the tethers of self-preservation, kin-sympathy, and love, and at other tethers, man tends to become religious; this is our central thesis. But religious activity is not a sublimation of older promptings; it is something new. That correlated harp-strings may vibrate when man is intensely religious is psychologically intelligible, and an activated correlate may become so strongly insistent that it drowns the strictly religious note or makes an unpleasant discord. Thus the religious reveries of some of the saints in bygone times are obviously more than coloured by sex-repressions, and some intensely self-preservative minds take refuge in religion as in

a transmundane form of insurance. In Professor William James's masterly analysis of religious experience good examples will be found of the treacherous way in which a correlated emotion may usurp the place of strictly religious feeling and may lead to a state of mind which must be frankly called pathological.

The psychology of religion requires no patronising recommendation. It is a vigorous, though young, branch of science, and it has many keen-witted devotees. Whatever it proves must be welcomed, and there is no reason why the religiously-minded should be afraid of the psychological analyst. But there is in the pursuit of inexact science a continual danger of hurrying to a conclusion, and the more unverifiable a conclusion, the more dogmatically it is defended. Therefore it seems useful to inquire whether we can hope at present to describe the essence of religious activity in terms of anything else. There are irreducibles in mind as well as in matter. No one doubts the reality of the powers of the "calculating boy," but it is not possible at present to account for them. The same is true of some other powers, and it may be true of religious feeling. There may be something in religion that cannot be psychologised into anything simpler. In a word, the mystical note may be regarded as an 'emergence.'

We are suggesting nothing magical, but merely the desirability of being cautious lest our conclusions

involve us in false simplicity. An illustration may be permitted. A man at the end of his physical resources may try a sun-cure and recover. In the present state of physiology it is not possible to account for all that happens. Certain factors are clearly understood, but there are residual phenomena which are not at present analysable. So, but at a much higher level, it may be with religion.

There is a gain in health when we expose ourselves to the sun, and the influence operates, mainly at least, through protoplasmic metabolism. We are not able at present to track out the complete nexus, but even if we could, it would not affect the sun-cure. Similarly, if we are enriched by "the grace of God," the influence operates, in part at least, through psychological processes. We are not able at present to analyse the process, but even if we could, it would not affect the value of the religious experience.

The hard-shelled sceptic may object, however, by indicating that in the case of the sun-cure there is the sun as well as the patient, whereas in religion there is only the patient—whose tendrils twine pathetically around one another. In the light of history and experience, this seems to be an unwarranted assumption. Unless there are influences from without—the "grace of God" their old-fashioned, perhaps truest, name—then religious activity is nothing more than an advanced course of Couëism. In the light of the facts of history and experience,

we say, this view seems unwarranted. The man restored to sight could not scientifically account for the influence, but there was not any illusion in his statement: "This I know, that whereas I was blind, now I see." No one doubts the power of music; there is more than self-hypnosis. Is not the same true of religion? To many people the question will seem as absurd as asking the cured patient if he believed in the reality of the Sun.

In this connection we venture to quote from memory an illustration used by Professor J. B. Pratt in one of his books. There was a country where most of the inhabitants were blind, including all the philosophers. But there were a few simple people whose eyes were not sealed, and they spoke of the joy of seeing the sun. "But," said the philosophers, "you must not talk in that excited metaphorical strain. There is a diffuse warmth, as we all know, but your talk about a visible luminous body is an antiquated objectivism. There is no sun." Yet the simple people asserted all the more that they saw the sun, and a psychological committee was appointed to investigate the matter. They made many experiments and in the course of time they discovered that whenever those whose eyes were not sealed said they saw the sun, they had opened their eyes. The blind psychologists felt over the seeing faces, and they made sure that there was a precise correlation between the openings of the eyes and the visions of the

sun. "Dear friends," they said, "you are suffering from an illusion; the image of the sun that you speak of somewhat unintelligibly is produced by this trick of opening your eyes. Be honest, now, and tell us if you ever behold the image of the sun except when you open your eyes." The simple seers said "No," and the committee was well pleased with them and hoped that they would recover from their sight. But the simple seers smiled to themselves, and went away saying: "We see the Sun."

The Culture of Personality

If it be granted that the personality of man at his best is a higher integration than the individuality of the horse, the practical corollary follows—that the acquisition should be fostered. It is a law of life that the unused, as well as the useless, undergoes degeneration. Nothing succeeds like success, but the organ that has ceased to be exercised degenerates, and the vestigial organ dwindles to a vanishing point. After three years in darkness a goldfish was found to be quite blind, having lost the rods and cones of the retina; and many dwellers in darkness are blind, whether by direct or indirect adaptation matters little.

There is a profound truth in the German poet's lines:

> "Was du ererbt von deinen Vätern hast
> Erwerb es, um es zu besitzen."

("What you have inherited from your forefathers,
Earn it, if you would make it your own.")

In other words, the talents must be trafficked with. Nature must be multiplied by Nurture. If this is true of ordinary characters, how true it must be of a subtle acquisition like Personality—the integration of the best of man at his best.

We admire and should emulate those who are enthusiastic over the training of the body, who have the ideal of physical vigour; we should also admire and emulate those who are enthusiastic over the culture of an all-round personality—in its cognitive, emotional, and conative activities. How well we know the need of discipline; how slow we are to gird the loins of the spirit.

History has demonstrated the integrative power of religion in national life. The cross and the sword have been the great unifiers. The same is true for the individual; he becomes in religion a new creature. And here we have one of the virtuous circles: the discipline of religion unifies the Spirit of Man, and that helps him towards a finer religion. Development, as well as Evolution, works on a compound-interest principle. "Unto everyone that hath shall be given; and from him that hath not, even that he hath shall be taken away." Can any one tell what the limits of religious integration are? Can any one be sure that there is not open to man a new emergence—the emancipation of the soul? Dare

Science bar these doors—*perhaps* the doors to life eternal?

There is already a large literature centred in the concept of Personality, and we are not suggesting that we understand this secret of our being. We are using the term to mean the integrated self—all of the self that is sufficiently controlled and harmonised to act as a unity. Since religion is an expression of the *personality* it is our duty and adventure to try to make the most of *that*, and just as there are disciplines for the protoplasmic life, so there are for the psychical. There are Coué exercises as well as breathing exercises, and he must be a fool who laughs at any of them or thinks he needs none.

But there is something deeper. A shallow view of personality—of which some would say that we are ourselves guilty—makes for a shallow religion. But, just as with Nature, a deep view tends towards a religious revelation. As Doctor J. S. Haldane says in his *Organism and Environment* (New Haven, 1917, p. 117): "It is the perception that in us as conscious personalities a Reality manifests itself which entirely transcends our individual personalities, that constitutes our knowledge of God." This seems to us to be the fundamental contribution that psychology has to make to religion. Well may we wish to be saved from taking profane views of our personality. Everyone is an Esau with his own particular "Red Pottage."

SUMMARY

(1) The chief problems are three: (*a*) Religion is a very personal affair; what has science to say in regard to human personality? (*b*) With what other strands in our personality is religious activity particularly correlated? (*c*) Does religious experience admit of psychological analysis, and, if so, how does that analysis affect the validity of religion?

(2) A survey of Organic Evolution discloses the large and luminous fact that there has been an increasing dominance of the mental aspect of behaviour. In reflexes, tropisms, and instincts there is automatisation of effective responses; but there is also a gradual evolution of the intelligent mind. At various levels, illustrated, for instance, by spiders and gorillas, there is evidence that mind counts as an operative factor. There is also discernible a growing emancipation of the Psyche. In the higher reaches of life there is more feeling and more understanding. This evolutionary trend towards the increasing dominance of mind is a big fact, admitting of religious interpretation.

(3) Evolution is characteristically integrative, and the ascent of organisms shows more and more thorough unification of life. This is brought about (*a*) by the nervous system, (*b*) by the circulation of the blood and especially by the regulative chemical messengers or hormones which are thus distributed from the ductless glands throughout the body, and (*c*) by psychical integration. In organic evolution there is a noteworthy evolution of the self—such as we are familiar with in the individual development of man. If the word "personality" be kept for man only we may use the humble term "individuality" for animals. The significant fact is that one of the great trends of organic evolution has been *towards* personality. This is a large fact, to be kept in mind in our religious interpretation of the realm of organisms.

(4) Man's solidarity with the rest of creation is an

indubitable scientific fact, but it should not be allowed to obscure his apartness, as manifested in his power of conceptual inference (reason), his language, his unified self-consciousness, his ethical conduct, and his social heritage. Towards this climax evolution has moved; there has been a consistent advance towards personality. In this great fact there is a suggestion of a promise. It may be that in the religious life, which is the highest development of personality, there is evolving a new psychical liberation. In any case, there is no contradiction between regarding man scientifically as the evolutionary crown of creation and regarding him religiously as 'the child of God.'

(5) Since religion is an expression of the evolving and developing human personality, great interest must attach to the question of the validity of this concept. What has modern scientific analysis to say about personality?

(6) The reality of personality has been attacked by materialism, which recognises nothing but matter and energy. But matter and energy are abstract entities reached by the human mind, and cannot account for a theory that there is no mind. It is only word-jugglery to say that matter can produce mind; they are incommensurables. Or one may simply stand by the fact that there is much in the world which cannot be described in terms of the categories of chemistry and physics. It does not seem that the reality of personality is touched by materialism.

(7) Somewhat subtler is the view of the epiphenomenalists and extreme behaviourists who regard "mind" as the mere byplay of cerebral processes. But we cannot make sense of animal behaviour, still less of human conduct, except on the assumption that mind "counts." The body-and-mind relation remains baffling, but whether we believe that the psychical musician plays on the material violin of his body and brain, or that the musician and the violin are two aspects of one elusive reality, the organism, the important fact is that there is music. We are sometimes predominantly mind-*Body* and sometimes predomi-

nantly body-*Mind;* the relation, if it be a relation, baffles statement; but the two aspects are equally real, and the integrated self or personality stands secure.

(8) The false simplicity of materialism has its counterpart, at a higher level, in what may be called "biologism," which overemphasises the animal nature of man and makes too little of the distinctively human. Another exaggeration is seen in the view that the ductless glands determine and dominate the personality. In normal cases they are certainly regulators, but a man should be bigger than his glands. There are other not less important factors in the inheritance—the nimble brain, the strong heart, the active liver, not to speak of good-will and power of control. Moreover, the personality is made as well as born; man is man and in normal cases should be master of his glands as well as of his fate.

(9) The validity of the concept of personality has also been threatened by the modern emphasis on the Unconscious. No doubt, there are many factors in life that are below the focus of consciousness. There are sunken memories, childhood's deep impressions; there are fundamental predispositions and urges; there are racial tendencies and ancestral impulses.

But the secondary, or Freudian, Unconscious consists of down-sunk "groups" of disharmonious ideas invested with emotion, "complexes" that have been repressed, but are ever seeking to assert themselves. They often emerge in dreams or become pathological eddies. Their power cannot be gainsaid, but there is little warrant for hypostatising them into a cunning Unconscious Self. It is man's prerogative to summon his unconscious motives and promptings before the tribunal of his conscious self—his reason, his ideals, his life-purpose. His personality is an active and growing integration which should counteract the fixing of repressed complexes, and religion is one of the activities in which what has to be suppressed may be sublimated. Deliberate *suppression* of the anachronistic,

as contrasted with automatic *repression*, is part of the ethical evolution of the race and part of the ethical development of the individual. In the Primary, wider than Freudian, Unconscious there is much in the way of prompting and inhibition that is altogether to the good. There is Original Righteousness as well as Original Sin.

(10) Religion has had a multiple origin, when men found themselves straining at the limits of their practical, emotional, and intellectual tethers. They sought after what showed promise of being a "life-giver"; they sought by sacrifice to placate mysterious powers of whom they were desperately afraid; they devised transmundane projections to explain the enigmas of their experience, such as the whence and whither of birth and death. Perhaps the first clear religious note was struck when men imagined the Great Mother. At a later period the first God emerges. Many minds recoil from the idea of fear-born religion, or of magic as a threshold, or of naïve mundane projections, but the dignity of an emergence is not affected by its genesis. Value is not affected by origin. Moreover, the later stages are not the isolated continuations of the crude early states. There is no piecemeal evolution. What came about was the evolution of man and his society, and religion was ever born afresh. It is the same with art.

(11) Correlated with religious activity—especially with religious feeling—are the self-preservative promptings, the social predispositions, and the love that is the flower of the sex-urge. Attempts have been made to show that religion is the sublimation of one or other of these, or of more than one. This is probably a confusion. For religion is very specific, and its keynote is mystical. In abnormal cases the correlates may rise into loud prominence and the truly religious note may be drowned. But religion was and is an emergence, a new note, with correlates certainly, yet distinct from them, itself and no other.

The value of religious experience is not lessened by psychological analysis, unless indeed the analysis becomes

apparently destructive by reducing religion to an illusion. That this is impossible seems to be shown by the facts of history and experience. In the present state of psychological analysis it seems that there are facts of religious experience which cannot be described in simpler terms. It must be kept in mind that religion implies not merely a sending out of tendrils but some reality on which they fasten. If there is not a transcendent or mystical influence that counts, then religious discipline seems not more than a high-grade form of Couéism. The facts of history and experience seem strongly *against* this second interpretation.

(12) Since religious activity is the highest discipline of our personality, and since religion has evolved in the race and does develop in the individual, it seems good sense that there should be an endeavour after a culture of the personality. Other things equal, a well-informed personality should have a finer religion than one that is ignorant, and similarly along other lines. It is not for Science to set limits to religious integration.

CHAPTER VI

A CONTRIBUTION TO NATURAL RELIGION

Does Science Contribute to Religion? What Science Discloses: Intelligibility, Order, Continuity. Beauty. Progress in Nature. Correspondences in Nature to Man's Ideal of Progress. Does Nature Admit of Religious Interpretation? John Stuart Mill's Arraignment of Nature. William James's One-Sided View of Nature. Huxley's Exaggeration of Individualism in Nature. General Conclusion: Naturalistic Description Does Not Exclude Transcendental Interpretation. The Scientific Account of Nature Is Essentially Congruent with the Religious Vision.

Does Science Contribute to Religion?

SCIENCE has come to mean so much to man—as torch to illumine and as rudder to control—that we cannot wonder at his desire to have it also as an aid to his faith. But this way lies disappointment. We cannot by scientific searching find out God. Science is impersonal and unemotional. We cannot base transcendent inferences on concrete data in regard to Nature. It is not by science that we can pass from Nature to Nature's God. The pathway is that of religious experience, just as the pathway to the vision of beauty is that of æsthetic discipline. It is possible, however, that science, with its disclosure of the Order of Nature and all its wonder, may suggest and enhance the religious view.

Let science grow from more to more, but man can-

not rest satisfied with an empirical formulation of what goes on; he must take an all-round or synoptic view, which is philosophy. With his science he must correlate what he learns by feeling and what he may infer from his moral experience and from the history of his race. What is *the meaning* of it all, is the question that is for most men irrepressible. It is not a scientific or an æsthetic question; it is frankly human; and those who admit its legitimacy—all except the strict positivists—are agreed that the answer likely to be nearest the line of truth, is that which takes into account most factors in human experience—the psychical life as well as the bodily, but the bodily as well as the psychical; the data of feeling as well as the results of science; all that has happened in the past as well as all that is taking shape now. In a word, the endeavour must be to see life whole.

What, then, has the scientific contemplation of Nature to contribute to the synoptic picture? It reveals to us an intelligible cosmos, an orderly flux, an advancing movement in which we share, a process in which there is progress, a world instinct with beauty. Is this total impression harmonious with the religious idea that Nature is in some sense a divine revelation? Is it congruent with the Vision of God, which may have come to us from a contemplation of the moral law within rather than of the starry heavens without, or which may have come to us through the discipline of the Christian religion? Or,

still more daringly, does the scientific contemplation of Nature in any way supplement or enhance our transcendental or religious concepts? If it is impossible to give some degree of affirmative answer to these questions, then we are bound to admit that there is no Natural Theology, no Natural Religion. The sooner we admit this the better, some would say; but there is a case to be stated for the opposite conclusion.

What Science Discloses: Intelligibility, Order, Continuity

It cannot be said that the naturalist's attempts to look at the world synoptically have been rewarded with more than chequered success. What we have reached is a sketch rather than a picture. The naturalist's path is bestrewn with unsolved problems as thickly as a road through a wood with withered leaves in autumn. He knows little about beginnings and little about the factors that have brought about the great results of evolution, such, for instance, as the emergence of living organisms, of backboned animals, of mammals, and of man. We have to take for granted a certain number of irreducibles, such as electrons and protons. We are not sure that we know more than a few of the real Laws of Nature.

There are large questions concerning human destiny, large questions as to the beginning and ending of the world, on which Science sheds no light. There

are deep-seated religious convictions, such as the belief in personal persistence after death, which raise great difficulties in the minds of students of science, especially when a monistic view of the organism is held.

There are other difficulties involved in the way in which scientific or religious conclusions are stated. Thus, the student of human heredity sometimes overstates the inexorability of entailment so as to leave the impression that it is impossible for a man to trade with his talents. And, on the other side, the religious truth in the doctrine of creation may be wrapped up in a form that is scientifically grotesque.

But after allowing for limitations and ignorances, we must not fail to appreciate the astounding and ever-increasing disclosure of the scientific 'intelligibility' of the world. Intelligibility is, in the first instance, a safer word than 'rationality,' for it simply implies that scientific formulation is possible. When we speak of the rationality of the world we may mean one of three things: (1) We may mean that the Laws of Nature commend themselves to our reason and are such as we should ourselves have thought out if we had been wise enough. But it must be remembered that the descriptive formulæ which we call "Laws of Nature" are probably in many cases far from being the fundamental laws. (2) We may mean that the cosmic process leads gradually and persistently towards results—such as Beauty,

Intelligence, Man, Society—which justify themselves more or less to us as rational beings. (3) Or, we may have in our minds the Aristotelian idea that there is nothing in the end which was not also in kind in the beginning. We know in ourselves the capacity for Reason, or conceptual inference, and we may argue back from that to an immanence of some kind of Reason in the beginning. "In the beginning was Mind." These may be true ideas, especially the second and third, but it is desirable in the first instance to keep to the fact of 'intelligibility.'

Science discloses a pervading order. The properties of things remain approximately the same, or, if they change, it is according to rule. There is no capriciousness. Winds and storms have their laws. There are accidents like landslips and earthquakes, discharges of lightning that blast trees and volcanic eruptions that smother villages, but in the actual occurrence there is no fortuitousness. Even when the complex sequences of living creatures have to be dealt with, we do not admit the fortuitous except as a convenient term for confessing that the preconditions are too intricate to allow of the prediction of the result. Even disease has its laws; there is an orderliness in the occurrence of disorder. We live in a cosmos, not in a phantasmagoria.

We see the dance of millions of dust particles in the air of a shaded room traversed by a beam of light. It is fortuitous in the sense that we cannot

unravel the complex of factors, such as diversities of temperature and hardly appreciable currents, but there is no disorder or arbitrariness. We see under the microscope the quivering Brownian movement of minute particles of Indian ink, but we know there is nothing haphazard in the paths and velocities of the invisible ions (travelling molecules or atoms) which knock against the visible particles and make them dance to and fro.

There are no mysterious disappearances in Nature. No matter, or energy, if one may distinguish the two, is ever lost. A brusque or freakish change in the course of generations is called in biological language a mutation or 'discontinuous' variation, but the 'discontinuity' simply means that the organism has passed suddenly, without intergrade stages, from one position of equilibrium to another. There is no more real discontinuity in a big step than in a little one. The only known apparent 'discontinuities' are those which are believed to be manifested when an electron whirling round the nucleus of an atom passes from one orbit to another, but this is a hypothetical construction which has not yet stood the test of time. The trend of science is to disclose—intelligibility, order, and continuity.

Beauty

Another impression is that of beauty—a quality of things which excites in us the æsthetic emotion.

Among living creatures that are fully formed and healthy and are leading independent lives in natural conditions, beauty is universal. It seems to be the hall-mark of orderly unified living, of stability from which all the discordant has been sifted out. It is the reward of the strenuous will to life; it is the mind shining through. It is no subjective illusion this recognition of the beautiful, but a revelation of the Spirit of Nature; and we see it in crystals and precious stones, in mountain and ocean, in the splendours of the sky and in the dust beneath our feet. Only when physical Nature is torn and gashed by forces still unbalanced is there a temporary ugliness, which Time soon proceeds to heal. Of course, Man can make almost anything ugly, but he is the exception proving the rule. The practical universality of beauty—except in readily intelligible cases like parasites and some half-finished embryos—is a great fact to be kept in mind in our interpretation of Nature.

Progress in Nature

The history of our world discloses a succession of advances, occasionally shadowed. It is like the advance of a victorious army—with some minor defeats, but victorious on the whole. Doubtless 'progress' is a human concept, not to be projected on Nature without careful consideration, but if we do not use the word we need some other, such as

"advancement," to describe *a fact*—the increasing differentiation and integration of the world. The whirling nebula became the sun and the planets, our earth and its moon. It must be admitted, whatever word be used, that the cooled earth was in two respects an advance upon the nebula—it was more heterogeneous and it had been brought nearer to still more significant steps. It was gradually becoming a possible cradle and home for living creatures. Its meaning had deepened. Living matter contains no elements that are not abundant in the non-living environment, but its emergence was an advance on the inorganic. It opened up new possibilities, which were previously not more than remotely implicit. As we survey the evolution of organisms, we see puzzling extinctions of creatures full of promise, we see the retrogressions of parasitism and strange eddies of beautiful organisms that seem never to join the general flow, but the big fact is a general advance. Among animals there is an increasing mastery of fate, a perfecting of differentiation and integration, a growing emancipation of the psyche with its inner life of feeling and knowing, with its real power of bending the bow of the body. Whatever be the relation of body and mind, what we call for convenience "the mind" comes to count for more and more. We feel the need of some word like *progress*.

Correspondences in Nature to Man's Ideal of Progress

Progress, as we have admitted, is a human concept. When we inquire into its meaning, we find that it implies two preconditions—health and wealth, and on the basis of these a balanced all-round movement towards a fuller embodiment of the true, the beautiful, and the good. That is what man at his best has always meant by progress.

But it is possible to go further. Man's highest endeavour is to make progress, and it is an open secret of great value that the main trends of Living Nature are in the same direction. The preconditions of human progress are *health*—positive health of body and mind—and *wealth*, which means a useful mastery of the forces of Nature. But Living Nature is all for health. Apart from parasites, there is practically no disease in Wild Nature. And, as for wealth, the reward in the struggle for existence is to those organisms that master their environment. In many of its aspects the struggle for existence is an endeavour after well-being. The central secret of life is accelerative accumulation of energy without proportionate tendency to dissipation. At many a turn in Living Nature, there is a rewarding of types that capitalise energy, whether in external or internal stores.

As for the beautiful, the true, and the good—has not the pursuit of these its clear counterpart in Living Nature? Beauty is Nature's hall-mark of

harmonious, vigorous life. Ugliness is her stigma of dishonour, hardly seen except in those creatures that adopt the parasite's drifting life of ease. Or it may be detected in some half-finished embryos, which are usually hidden carefully away. As Meredith said: Ugly is only half-way to a thing.

Seeking the truth is a noble aim, which one would not belittle by any biologism, but is it not in some measure the expression of the healthy mind, which faces the facts and is intolerant of obscurities? And has not the reward of success and satisfaction come especially to those animals that face the facts and are clear-headed? Even among animals there is a trend that makes against dull stupidity and puts a premium on brains.

The practice of Self-Help is conspicuous in Animal Nature, but so is Mutual Aid. The Economy of Nature, with its regime of continuous reincarnations, implies an emphasis on self-preservative activities, but in many cases a large proportion of the time and energy of animals is devoted to ends which are other-regarding, especially those that secure the welfare of the young. Speaking metaphorically, we may say that Nature gives her premier place to creatures, like birds and mammals, which excel in parental care and display the virtue of self-subordination. Good parents, good lovers, good kin do by no means lose their reward. We deliberately advance the thesis that man's pursuit of the beautiful, the true,

and the good has its adumbration in Living Nature. Organic Evolution in its main trend is progressive in the deeper sense. Instead of Man in his ethical endeavours having to turn his face against the direction of the cosmic process, he has rather to get more into line with it. The evolutionary momentum is with man at his best. It finds expression in some of the fibres of his being and in the social system which he has developed.

When we think over the intelligibility, the order, the beauty, the advance, and the progressiveness of Nature, we feel that the world is more divine than dæmonic, that it is not unlike a great thought, that it is congruent with the concept of a Creator. In any case, the more we know of the world, the more it becomes like a home in which the religious can breathe freely. There seems a strange impiety in Luther's brusque remark: "The world is an odd fellow; may God soon make an end of it"; but perhaps he was thinking chiefly of the world of men. There is a nobler thought in Psalm 19:

> "The heavens declare the glory of God,
> And the firmament showeth forth His handiwork,
> Day and day welleth forth speech;
> Night unto night breatheth out knowledge,
> There is no speech and there are no words,
> Yet their voice reverberates through all the earth."

The psalmist reached forward to the daring idea: Vox Naturæ, vox Dei.

Criticism.—The thesis which we have submitted is that there are in the Realm of Organisms great movements which correspond in their general trend with those expressed in man's concept of progress. If this is a valid conclusion it is important; if it is fallacious it must be abandoned—pious opinion though it be. Let us try to anticipate criticisms.

It is not suggested that Animate or Living Nature works deliberately towards health or beauty or species-regarding or any such end. What is asserted is that the processes of selection lead to these results, which have survival value. And yet we must not think of Living Nature as if it operated mechanically like a machine which automatically separates light or heavy coins as they come from the mint. For variations and mutations are expressions of the implicit organisms which are known as the germ-cells, and if they come to stay they must be congruent with the antecedent constitution. Moreover, we see that organisms are not passive pawns that are shifted hither or thither; they share actively in the game. Organisms play the cards which heredity puts into their hands. Thus, to take a diagrammatic case, a spider of a peculiar colour has been known to take up its position on a background where it was practically invisible. While the processes of selection are not deliberate, they are not always automatic.

Our thesis does not press the subjective aspect; it

simply states the objective fact that the evolutionary process favours the analogues of what we call clear-headedness, beauty, and altruism. We are well aware that only a few animals show any hint of intellectual curiosity, but that is not inconsistent with a premium being set on a capacity for appreciating a situation. Except in a few cases, like the bower-birds, it is difficult to make out a strong case for the presence of æsthetic emotion among animals. But that is not inconsistent with the fact that almost all wild animals *are* beautiful, and that some of them express themselves in very beautiful handiwork, such as a garden spider's web or the nest of a chaffinch.

"I believe a leaf of grass is no less than the journeywork of the stars,
And the pismire is equally perfect, and the grain of sand, and the egg of the wren,
The running bramble would adorn the parlours of heaven,
The tree-toad is a masterpiece for the highest,
The narrowest hinge in my hand puts to scorn all machinery,
The cow crunching with depressed head surpasses any statue,
And the mouse is miracle enough to stagger sextillions of infidels."

We do not in our thesis suggest for a moment that animals are ethical agents, though there are undeniable adumbrations when gregarious creatures observe certain conventions, or when a dog, after prolonged partnership with man, develops something approaching a conscience. Indeed, it seems to us a confusion of thought to expect in animals any more than occasional far-off hints of an ethical judgment.

They do not control their behaviour in reference to general ideas or ideals. What we are interested in at present is the extent to which animals exhibit the raw materials of the virtues—rising sometimes to admirable heights of self-sacrifice. If the process of organic evolution rewarded only those that sharpened teeth and claws and excelled in self-assertive hustling—admirable activities within limits—the picture would be more difficult than it seems to us to be. What we see is a generous rewarding of those animals whose strength is their gentleness, and we submit that few naturalists have appreciated the organic altruism displayed at many levels in the animal kingdom. No doubt it is their meat and drink to be self-sacrificing parents; it is part of their constitution, just as it is wrapped up in the worker-bee to wear its brain out in a few weeks in the service of the hive.

Animals in general are in the strict sense non-ethical, but their springs of conduct are often admirably altruistic—if we may use the word objectively. One should remember, moreover, that man cannot be a moral Melchisedec; he has strands of virtue in his constitution which are much older than he.

Does Nature Admit of Religious Interpretation?

Our question is whether the scientific description of Nature is congruent with the religious interpretation that the observed order and progress are ex-

pressions of the Divine thought and will. To some minds an answer in the affirmative is impossible, because of the shadows, disharmonies, and incongruities which seem to them to spoil the picture.

Perhaps, however, we should not in our survey give too much prominence to Man and his works, for he is relatively a newcomer and in process of rapid evolution. We are to think of the original handiwork of God, not of the effects of man's prentice hand in domestication and cultivation, disease-spreading and disfigurement. It is plain that man, who exterminates Birds of Paradise and rare antique types, who shoots gorillas and cuts down forests without replanting, has still much to learn.

Another of the difficulties is expressed in Tennyson's phrase, 'Nature red in tooth and claw with rapine.' This sanguinary aspect is undeniable; what are we to say? We must remember the value of struggle, from which even man cannot remove himself without running great risks. We must recognise that the struggle often takes finer forms than internecine competition. We may dismiss the "cruelty of Nature" as an anthropomorphism, since death usually comes in the twinkling of an eye. If we are bold enough to disapprove of the existing economy of Nature in which animal eats animal through a long succession of reincarnations, we must confess that we have no evidence that any other scheme would have worked. A vegetable economy of Na-

ture would have kept the mind in prison. A universally vegetarian animal regime is conceivable, but it is not likely that it would be either progressive or permanent. Were there not carnivores and insectivores the world would soon become uninhabitable. We must dismiss the reproach of wastefulness as another anthropomorphism; Nature has to work with a big margin; the teeming multitudes of small fry make higher life possible. We must admit the fact that in Animate Nature the infantile mortality is prodigious: "so careful of the type she seems, so careless of the single life." Yet it is interesting that the chances of death decrease as the individual life rises in value. One young oyster may survive out of a million, but the Golden Eagle is not likely to lose either of its eaglets.

The ground is shifted a little when the critic of Nature points not to the "gladiatorial show" aspect (as Huxley called it), nor to apparent cruelty and wastefulness, but to the elimination of magnificent types which leave no direct descendants. It is not the replacement of generalised ancestors by specialised descendants that is puzzling, as in the case of modern horse and elephants, whose predecessors are all extinct. The difficulty is in regard to fine races like the Flying Dragons or Pterodactyls, which have disappeared without leaving any descendants. How can we give any reasonable explanation of "lost races"? We may point out that they had their day

—sometimes a Golden Age, and that in many cases it was not a short one. We may suggest speculatively that they were of indirect service to the advancement of other races that have persisted. For they may have formed a useful part of the Systema Naturæ of their age. But the sounder answer is perhaps to be found in a frank recognition of the artistry in Nature. Room must be left for what we might metaphorically call imaginative byplay. The unconscious artist throws beautiful sketches on the studio floor. Tentatives are central to the process of organic evolution, and the fact that some have succeeded may imply that others had to be failures —sometimes glorious at that.

Many perplexing facts rise in the mind when we venture to think of Animate Nature as an expression of the Will of God; but it is likely that these will become more intelligible as Science grows, for there are many pages in the book still unread. It must be admitted that there are imperfect adaptations, such as we witness when a magnificent tree becomes too heavy for its roots and is brought to the earth by the wind while still in its prime. But evolution is a process still going on, and some adaptations are almost demonstrably in course of improvement. Man has vestigial relics of his ancestry that are apt to be troublesome, but he is plainly in process of transition, and we can hardly make a difficulty out of the discomforts that he brings upon himself by altering

his habits and environment in a way or at a pace that taxes the plasticity of his organism. One is often disagreeably impressed with the number of parasites which destroy fine organisms, but the most deplorable cases are associated with human interference, where overcrowding, or oversheltering, or some artificiality of environment has made a plague possible. The Grouse has usually thousands of intestinal parasites, but they do not seem to do appreciable harm unless the over-preserved birds become weakly. In most cases a give-and-take is established between host and parasite; the dire cases are those where a new host, without natural counteractives, comes within the circle of the parasite's distribution, as when horses are brought within the Tsetse-fly belt and are infected with a Sleeping Sickness organism which the insect disseminates. Shadows and disharmonies are not lacking in Animate Nature, but they become less perplexing as they are faced.

To many minds the greatest difficulty in the religious interpretation of Nature is centred in the word Purpose. Is there a purpose in the cosmic process from nebula to cooling earth, from amœba to man, and, if so, what is that purpose? This is the most difficult question that we can ask in regard to Nature. It is a common practice in every-day life and also in philosophical interpretation to shed on a process the light of its outcome. In other words, we

must envisage a process as a whole. When we think of man and his achievements we recognise an outcome that is not, so far, an anti-climax. Whatever may be his destiny, in regard to which Science has no light, man is an achievement that may be said to justify the inconceivably long groaning and travailing of creation. The course of evolution, especially when we consider its main trends, and the highroad as contrasted with the byways and blind alleys, *looks as if* it had been prearranged with a view to the emergence of man. It looks as if Nature were Nature with a purpose.

It must not be hastily said that 'purpose' is not a scientific concept. On the contrary, it is absolutely necessary when we are describing human conduct or animal behaviour in its higher reaches. We may speak of conceptual purpose in a reformer, or of perceptual purpose in an elephant, or of instinctive purposiveness in an ant or a bee. But while this is true, it has to be admitted that the concept does not grip when it is applied to the Order of Nature or to the process of evolution. Purpose is a quality of life and mind, of some agent that has attained or is approaching personality. If the concept be used in regard to Nature, it must be ascribed to the Creator, the Author of the Order of Nature, the Prime Mover—God.

Unless we are mere drifters with the tide—human Plankton, not Nekton—we recognise purpose as the

central reality in our life. It is, therefore, almost impossible for us not to use the concept in our interpretation of the cosmic process. Behind all, we say in religious language, there is the Will of God. But there can be no scientific proof of this or any other religious truth.

If we religiously recognise a Divine purpose in Nature, it does not follow that the process of evolution has been *immediately directed*, as many religious minds wish to believe. It may be that the Creator endowed the "irreducibles"—such as electrons and protons and 'mind'—with autonomy. There is such a thing as *indirect* direction.

One of man's extraordinarily ingenious devices is the "Gyropilot," by means of which a steamship can be automatically steered from New York to the Mersey. The vessel's direct course is set and thereafter no interference is necessary, unless indeed something unpredictable occurs, such as the approach of an iceberg or another ship. If winds or currents should tend to bear the vessel to the south, this is automatically corrected by adjustments which keep the vessel to its set course. Is the vessel humanly directed if the quartermaster never touches the wheel? The answer must be "Yes" and "No." The "no" expresses the fact that the steering is automatic; the "yes" expresses the fact that man devised the "gyropilot" and set the vessel's course. So there may have been an indirect direction in evolu-

tion, though the process, once started, required no further guidance. But this is not to say that God does not keep the world in mind, if we may use simple words in reference to the deepest metaphysical problem.

In all these questionings, it must be recognised that our words are far too small. Just as man's conceptual purpose, when he has one firm and clear, is far above the perceptual purpose of an elephant, when it has one, so it must be if we dare to speak of the Divine purpose. "For His ways are not as our ways, nor His thoughts as our thoughts."

Also to be kept in mind, with reverent common sense, is the obvious fact that we are like children reading a book of which the beginning and the end are unknown, which has many missing pages and others glued together, which is not all in the same language. Who are we that we should proclaim it inconsistent?

John Stuart Mill's Arraignment of Nature

The most unrelenting arraignment of Nature that we know is John Stuart Mill's. It will be found in the first of the three essays—*Nature, The Utility of Religion and Theism* (London, 1874). Let us listen to it:

(1) "Next to the greatness of these cosmic forces the quality which most forcibly strikes every one who does not avert his eyes from it, is their perfect and

absolute recklessness. They go straight to their end, without regarding what or whom they crush on the road."

The answer is that we cannot conceive of a world of favouritism. As Pope said, "Shall Gravitation cease when you go by?" There can be no loopholes in a Cosmos. No one would hesitate between a world where consequences are unpitying and a world of caprice. Moreover, it is the very callousness of Nature that has made it such a good school for beast and man. But we may go further and turn the tables on the critic of Nature by pointing out the many ways in which life is fostered. The flood sweeps thousands of living creatures to destruction, but what is that compared with the beneficence of the circulation of water? The sandstorm smothers, but what is that compared with the underground retreats which the penetrability of the soil offers to the thousands of burrowing animals? The angry waves strew the shore with animal wreckage, but what is that compared with the kindliness of the sea as the greatest of cradles for young life?

(2) Mill's second accusation is 'cruelty.' "Killing, the most criminal act recognised by human laws, Nature does once to every being that lives; and in a large proportion of cases, after protracted torture such as only the greatest monsters whom we read of ever purposely inflicted on their living fellow-creatures." But we have very little evidence of pro-

tracted torture; death is oftener instantaneous. We have not much warrant for speaking of great pain, except in the highest animals. The wasp curtailed of half its body will continue sipping jam, and the legged part of an ant may work for hours after losing all the rest. Most of the talk about "the cruelty of Nature" is rank anthropomorphism. Alfred Russel Wallace was very kind-hearted, certainly one of William James's "tender-minded" types, and yet what does he say out of his unusually wide experience of Wild Nature? "On the whole, then, we conclude that the popular idea of the struggle for existence entailing misery and pain on the animal world is the very reverse of the truth. What it really brings about is the maximum of life and of the enjoyment of life with the minimum of suffering and pain." (*Darwinism*, 1889, p. 40.) What did Darwin say? "When we reflect on this struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply." (*Origin of Species*, 6th ed., 1872, p. 61.)

The scheme of Living Nature is a continual sequence of embodiments or incarnations, in an endless chain, and the possibility of higher forms of life depends on broad foundations among the lower. We do not say that there are myriads of minute crustaceans in order that there may be fishes; but

we do say that the crustaceans make the fishes possible; just as fishes make fishermen possible. It is idle to talk of Nature's wastage or of a massacre of the innocents; these ideas do not grip. Moreover, Man does not manage his own affairs so well that he dare arraign Nature for removing animals before they have begun to age.

Throughout Nature there is a continual—sometimes noisy—conjugation of the verb "to eat"; the system of Nature is careless of the single life; death, as Goethe said, is Nature's device for securing abundance of life—all that is true; but the reproach of cruelty is illegitimate. And against the competition to the death, the sanguinary conflict, the occasional cannibalism, we have to set the co-operation, the mutual aid, the parental care—not less conspicuous.

Mill seems to have been greatly impressed with Nature's cruelty to Man. "Nature impales men, breaks them as if on the wheel, burns them to death, crushes them with stones like the first Christian martyr, starves them with hunger, freezes them with cold, poisons them by the quick or slow venom of her exhalations, and has hundreds of other hideous deaths in reserve, such as the ingenious cruelty of a Nabis or a Domitian never surpassed. All this, Nature does with the most supercilious disregard both of mercy and of justice, emptying her shafts upon the best and noblest indifferently with the meanest and worst. Anarchy and the Reign of Terror are

overmatched in injustice, ruin, and death by a hurricane and a pestilence."

The answer must be that Man is a restlessly experimental creature and that he is characteristically unafraid in his attempts to enter into his kingdom. Out of his defeats come his subsequent victories. It is not Nature's fault if Man builds his village on the flanks of Vesuvius; it is not Nature's fault if man exposes himself recklessly to parasites like hookworm; it is not Nature's fault if man does not build his dam strong enough; it is not Nature's fault if man's careless disposal of crumbs brings about a plague of rats, with the Black Death as an aftermath. "Many evils," said Maarten Maartens, "are not of God's appointing, but of Man's approving."

Mill brushed aside impatiently the suggestion that Nature's inflictions are there for our good. If so, he asked, why are we so keen to get rid of them? Moreover, the fact that the crimes of men have sometimes had some good result, does not make them less criminal. But this seems too anthropomorphic and anthropocentric. The pestilence is not arranged as a punishment for man; it is not an expression of Nature's *vendetta;* yet it is a defeat from which Man may learn. There is great wisdom in Goethe's aphorism: "Nature creates man dependent upon the earth, dull and heavy; and yet is always shaking him until he attempts to soar above it."

Mill seems to miss the mark when he accuses Na-

ture of being indiscriminate in her frustration of man's efforts, mowing down with ruthless scythe. One must admit that a careful and cleanly citizen may fall victim to the state of his careless neighbour's drains—there is an element of the fortuitous; and the conditions of microbic infection take little, or it may be no, account of persons. Indeed a world of providential favouritism does not commend itself to the modern outlook. Everyone will also admit that there is sometimes quite indiscriminate reduction of numbers, as in a great earthquake or as in a plague, which removes strong as well as the weak. Yet, on the whole, the facts are otherwise—the whole point of Darwinism is its disclosure of *discriminate* elimination, of genuine *sifting*, so that the relatively fit survive. "Fit" does not necessarily mean strong, clever, beautiful, kindly, or anything that man ranks as good; but it sometimes does. And Nature's sifting of Man is certainly not indiscriminate. The parable of the builders gives us the true picture:

"And the rain descended, and the floods came, and the winds blew, and beat upon the wise man's house; and it fell not: for it was founded upon a rock."

"And the rain descended, and the floods came, and the winds blew, and beat upon the foolish man's house; and it fell; and great was the fall of it; for it was built upon the sand."

That is the kind of sifting to which Nature has subjected all her children—including Man.

The poets often get nearer the truth than do the philosophers.

Take Tennyson's familiar lines:

> "For life is not as idle ore,
> But iron dug from central gloom,
> And heated hot with burning fears,
> And dipp'd in baths of hissing tears,
> And battered by the shocks of doom
> To shape and use."

Or Meredith's:

> "Behold the life of ease, it drifts.
> The chastened life commands its course,
> She winnows, winnows roughly, sifts
> To dip her chosen in her source,
> Contention is the vital force,
> Whence pluck they brains, her prize of gifts."

So far from Nature's eliminations being indiscriminate, they have been persistently winnowing. And the "dilemma of civilisation" is just this, that man, with his growth of social sympathy, has rebelled against Nature's regime of inexorable sifting—eliminating the unhealthy, the unstable, the uncontrolled—without having as yet substituted for it an adequate rational selection. A return to the crudest forms of the struggle for existence is extremely unlikely among civilised peoples, though the Great War has shown, amid its heroisms, that barbarism is less remote than we thought; but to the biologist it seems plain that some form of selection is the *sine*

qua non of safety. It is man's task, however, to change the coarser forms of the human struggle for existence into an endeavour after well-being.

From his arraignment of Nature Mill drew two conclusions. The first was that it is irrational and immoral to follow Nature. Irrational, because if we wish our actions to be useful, we must see to it that they are improvements on the spontaneous course of Nature; immoral, "because the course of natural phenomena is replete with everything which when committed by human beings is most worthy of abhorrence."

No doubt Man has persistently tried to control Nature, to bend the forces of Nature to his purposes, and sometimes he has succeeded in improving on Nature. Thus, the Marquis Wheat, which helped to win the war, is a great improvement on the Wild Wheat of Mount Hermon; and the dog is in many respects an improvement on the wolf. But it does not seem to have occurred to John Stuart Mill that man's best results on the lines of cultivation and domestication have been reached by following Nature's method of Selection. That man may also make headway by following in his ethical endeavours some of the main trends of Organic Evolution, is quite certain; it is enough to think of the rewards that Nature has given to self-subordinating, other-regarding types like birds and mammals.

The second conclusion which Mill drew from his

criticism of Nature interests us even more. It was that the government of Nature could not be the work of a Being at once good and omnipotent. His view was that "the Principle of Good *cannot* at once and altogether subdue the powers of evil, either physical or moral; could not place mankind in a world free from the necessity of an incessant struggle with the maleficent powers, or make them always victorious in that struggle, but could and did make them capable of carrying on the fight with vigour and with progressively increasing success. Of all the religious explanations of the order of nature, this alone is neither contradictory to itself, nor to the facts for which it attempts to account" (p. 39). It is man's duty to stand forward "a not ineffectual auxiliary to a Being of perfect beneficence."

This, it will be observed, was a definitely *religious* view, and it is familiar to us in the writings of William James. "Life *feels* like a real fight—as if there were something really wild in the universe which we, with all our idealities and faithfulnesses, are needed to redeem; and first of all to redeem our own hearts from atheisms and fears. For such a half-wild, half-saved universe our nature is adapted." (*The Will to Believe and other Essays*, 1905, p. 61.)

In the advice given to man by John Stuart Mill and William James there are two sound ideas: (1) That man must continue to struggle if he would keep his foothold, and still more if he would advance;

and (2) that man may be helped to find himself by mastering Nature—provided that when he takes science in one hand he takes good-will in the other. For mere increase in power will not save man from devilry.

On the other hand, in spite of the Scriptural idea of being "fellow-workers with God," which refers to ethical and religious endeavours, there seems something approaching the ludicrous in the idea of present-day man acting as auxiliary to God in improving the world! It must be admitted that apart from a few domestications and cultivations, in which he has followed Nature's methods, man has not shown great aptitude in improving the world without. In most cases the impression one gets is that "every prospect pleases and only man is vile." Until man has made more progress with the cultivation of his own personality we distrust his landscape-gardening of Wild Nature—supposed by philosophers to be in great need of improvement.

William James's One-Sided View of Nature

No one can forget the terrible indictment of Nature in William James's essay, *Is Life Worth Living?* "Our sacred books and traditions tell us of one God who made heaven and earth and, looking on them, saw that they were good. Yet, on more intimate acquaintance, the visible surfaces of heaven and earth refuse to be brought by us into any intelligible

unity at all. Every phenomenon that we would praise there exists cheek by jowl with some contrary phenomenon that cancels all its religious effect upon the mind. Beauty and hideousness, love and cruelty, life and death keep house together in indissoluble partnership; and there gradually steals over us, instead of the old warm notion of a man-loving Deity, that of an awful power that neither hates nor loves, but rolls all things together meaninglessly to a common doom."

But there is need for some evidence of the accuracy of this view of Nature. "Hideousness," James says; but there is no ugliness, far less hideousness, in Wild Nature. "Cruelty"; but this is an irrelevant ethical term, and anything like prolonged pain-giving is extremely rare in Wild Nature. Beauty crowds us everywhere and a large proportion of the time and energy of many animals is devoted to securing the welfare of their offspring. "Meaninglessly to a common doom," James says; but evolution is on the whole integrative. Lotze was nearer the truth with his "onward advancing melody." Is not William James's arraignment of Nature based on a nightmare view—distorted and on the whole fictitious?

There is reason to linger over the position taken by this great philosopher and great man, for it seemed to him that the "real and genuine discord" carried with it "the inevitable bankruptcy of natural religion naïvely and simply taken." Unless Nature

can be interpreted as in some measure a revelation of the Divine, then there is no Natural Theology. And how can Nature be an expression of the Divine if it is as William James supposed it to be? "Visible nature is all plasticity and indifference—a moral multiverse, as one might call it, and not a moral universe. To such a harlot we owe no allegiance; with her as a whole we can establish no moral communion."

There is a danger of losing oneself in words. In a strict sense, no doubt, the ethical note is not sounded in Nature. Animals are affectionate and kindly, good parents and loyal kin; they have plenty of virtues—the raw materials of morality. But no one supposes that they "think the ought," that they live an ethical life, controlling their behaviour in the light of ideals. That is man's prerogative. But it is nevertheless quite possible that Nature may be, as Professor Patrick Geddes called it, "a materialised ethical process." For the rewards of survival and success, often given to the self-assertive, are also given to the self-subordinating. Even in Natural Selection there is an adumbration of the idea that the individual's death is unimportant when the interests of the race are at stake.

We agree with William James that "if there be a divine Spirit of the universe, Nature such as we know it cannot possibly be its *ultimate word* to man"; but we think there is more revelation in Nature than

the philosopher discerned. The fact is that William James thought natural religion had suffered "definite bankruptcy," and he was not very sorry. He saw in Nature no harmonious spiritual intent, only *weather*. He speaks of men of science whose goodwill exceeds their perspicacity, who keep publishing natural religion in new editions, but for his part he was tired of it.

The question is whether he was not much too hasty, whether he knew enough about Nature. Think again of the order of the world, the ubiquitous beauty of Animate Nature, the almost universal healthfulness—always excluding cases where Man has interfered. Think of the rarity of the unlit lamp and the ungirt loin among animals. Think of the parental care, the mutual aid, the kin-sympathy, and the rewards of these. Think of the persistent trend towards more mind and more kindly feelings. Why, Nature is no harlot, but an Alma Mater.

The pictures of Nature drawn by John Stuart Mill and William James seem to us to be out of perspective and off colour. But have they not a deeper defect in tolerating a Manichæan view of the world? A temporary lack of fulfilment one may admit, not only in man but in some corners of Nature where disharmony lingers. Every art is limited by its medium, and there is no reason to suppose that evolution has stopped. But that is very different from tolerating the idea of a primary or radical Manichæ-

ism. We hold to the optimism of the simple words: "And God saw that it was good."

Huxley's Exaggeration of Individualism in Nature

Neither John Stuart Mill nor William James had any intimate acquaintance with Animate Nature, but it is very different when we come to Huxley. It must be noted, however, that he was, as he himself says, more of an engineer among organisms than a field naturalist. That is to say, the great zoologist was more interested in anatomy and physiology than in Natural History.

In the famous lecture on Evolution and Ethics, Huxley's argument was that Animate Nature is too much like a vast gladiatorial show, a Hobbesian warfare of each against all, a dismal cockpit, an inexorable struggle for existence, the result of which is merely the survival of the most suitable, not of the best in any sense. "Let us understand, once for all, that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it." "The practice of that which is ethically best—what we call goodness or virtue—involves a course of conduct which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence."

What is wrong here is the one-sidedness of the picture, for the struggle for existence is a formula covering all the answers-back that organisms make to

environing difficulties and limitations, including experiments in co-operation as well as in competition, in parental care as well as in predatory devices, in self-subordination as well as in self-assertion. In the appendix to his lecture, Huxley shows that he had some appreciation of this, for he says a little in regard to gregarious habits and animal societies. He makes the admission that "the general cosmic process begins to be checked by a rudimentary ethical process." On the whole, however, he sticks to his position that the cosmic process has "no sort of relation to moral ends," and he goes the length of saying that "the thief and the murderer follow nature just as much as the philanthropist." This is an untenable position, for the cosmic process has blossomed into social virtues, and it cannot be said that either thief or murderer is following the main trend of intraspecific evolution in the higher animals.

General Conclusion

Our main question has been: Is the scientific account of Nature congruent with religious interpretation? Or, to put it negatively, is there anything in the scientific description that makes it difficult or impossible for us to regard Nature as in some sense a Divine revelation? We have ventured to maintain that the world described by science is one in which the religious mind can breathe freely, and we have given the following reasons: (1) Science discloses

the intelligibility, the unity, the order, and the advance of Nature. (2) When we consider the persistent way in which advance in Nature has been secured throughout hundreds of millions of years, the apparent conspiring of conditions that facilitate the advance, the way in which broad foundations are laid that make further advances possible, the gradually increasing dominance of 'mind' in the higher reaches of life, and the illumination of the whole process when we see it in the light of Man, who is at his best a not unworthy climax, there is a cumulative suggestion of purpose. But purpose cannot reside in the System of Nature; it must be referred to an Author. (3) There seems to be significance in the fact that certain great trends in Organic Evolution are in line with man's endeavours after progress. There is an evolutionary momentum in a progressive direction that finds expression in the fibres of our individual being and in the fabric of human society. (4) Science itself is a phenomenon suggestive of a deep significance in Nature. Its achievements are such that it is difficult to think of them unless they are expressions in man of something larger than his own personality.

Some may be inclined, however, to raise the previous question: Why should we seek after any religious interpretation at all? In indicating the lines of an answer to this question we are reminded of a heading in one of the leading newspapers in the Spring of

1924: "Religion No Longer Compulsory." The reference was to a change of the law in Austria, recognising the legitimacy of leaving one "confession" without embracing any other. But the heading by itself suggests that there is little use in discussing the value of religion with those who are not troubled by questions which science cannot answer, or by the ethical disharmonies of their own nature, or by overwhelming emotion; or who regard everything 'mystical' as an illusion. But if the question is not thus foreclosed, we may return to the thesis of our first chapter, where it was indicated that it is natural for man to send out tendrils in search of a spiritual order of reality when he finds himself at his intellectual, practical (ethical chiefly), and emotional limits. That these tendrils simply coil on themselves is a rationalistic interpretation which does not seem to cover the facts—in the lives of the saints, for instance.

It is difficult to keep from pressing certain questions whose answers lie beyond science: What is the meaning of this cosmic process lasting for hundreds of millions of years; what is the meaning of man and his high thoughts; will there be anything to show for it if the earth should wax old like a garment? To use the sarcasm of Anatole France, will God then say to his courtiers: "That was a good play, let us have it over again"?

Careful inquiry has shown that in the childhood of

religions there was often a search for "givers of life," and that kind of tendril continues to grow. In many respects man is still "an infant crying in the night, and with no language but a cry." But in modern times, it is for the grace of God, rather than for material benefits, that he cries—if he cries at all.

Man may be borne into religious experience by a high tide of emotion; and we are particularly interested here in that emotion which is excited by the beauty and wonder of Nature. It is necessary to distinguish in theory two sets of cases: Those in which religious feeling already present, for instance through the acceptance of a religious tradition, is encouraged and enhanced by the mystery of the mountains, or the starry firmament on high, or the beauty of birds and flowers; and those in which Nature is itself the fountain and origin of the religious feeling. Of its sincerity in both cases there can be no doubt. Attempts to psychologise it into the ordinary seem to us to be as unsuccessful as the attempts to merge the æsthetic emotion with the urge of sex. Wordsworth knew the Nature-prompted religious emotion when he wrote of:

"A sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thoughts,
And rolls through all things."

Ruskin knew the Nature-prompted religious feeling when he wrote the words, now carved on the memorial stone at Keswick: "The Spirit of God is around you in the air that you breathe, His glory in the light that you see; and in the fruitfulness of the earth and the joy of its creatures He has written for you day by day His revelation, and He has granted you your daily bread."

In this connection we may recall Saint Augustine's lament that he had been so long in finding God: "I have loved thee late, thou Beauty so old and so new, I have loved thee late."

We need religion because without its postulates we cannot rationalise our experience; we need religion in emotional and ethical crises; but when religion unfolds like a flower in the quiet atmosphere of Nature-contemplation we enjoy an enrichment of our being. Too often perhaps is religion spoken of as a support to baffled intellect, or as a crutch when we have lamed ourselves, but the Nature-prompted religious feeling suggests a different aspect—the enrichment of our personality from without. There does not seem anything preposterous in the idea that man should receive something from Nature analogous to that which he receives from Art—from music in particular—for Nature is a great artist; and there may well be more in heaven and earth than is comprised in naturalistic philosophy—which is not to be confused with naturalistic science, to which,

of course, we firmly adhere. And just as no one expects to be much benefited by music or paintings if he is utterly preoccupied with, let us say, bodily disharmonies, so to be enriched by Nature may reasonably demand some preparedness.

It is often said that religion is a projection of the best that is in us, and if we are able to form any conception of God we cannot hope to free it wholly from human symbolism. From this anthropomorphism there is no escape, not even in the unsurpassed words of the catechism: "God is a spirit, infinite, eternal, and unchangeable in His being, wisdom, power, holiness, justice, goodness, and truth." The history of religions shows clearly that as man's needs grew—in height and depth, as well as in length and breadth—his God also grew. So it must continue to be, and one of the needs of the religious mind to-day is an appreciation and interpretation of the world which modern science describes. This must enter into our conception of God.

If religion implies a projection of the best that is in us, an obvious practical corollary is the need for cultivating the personality. As Sir Thomas Browne said in his *Religio Medici:* "Have a glimpse of incomprehensibles and thoughts of things which thoughts but tenderly touch; lodge immaterials in thy head; ascend into invisibles; fill thy spirit with spirituals, with the mysteries of faith, the magnalities of religion, and thy life with the honour of God."

But when we speak of the necessary projection of

the best that is in us, we must not forget the other aspect of religion, that it is an opening of our nature to the best that is outside of us—in good men and women, in the lives of the saints, in human history and all that has happened there in the way of revelation, and in Nature which is also a revelation. "There are two books," said Sir Thomas Browne, "from which I collect my divinity: besides that written one of God, another that of his servant Nature, that universal and public manuscript that lies expansed unto the eyes of all; those that never saw him in the one, have discovered him in the other." The chief aim of this book has been to make it easier to discover God in the "universal and public manuscript" by showing that scientific description in terms of Lowest Common Denominators cannot be in any *radical* antithesis with religious interpretation in terms of the Greatest Common Measure.

SUMMARY

(1) Scientific data do not in any direct way furnish a basis for religious conclusions. But science, with its disclosure of the Order of Nature, may suggest and enhance the religious view. If we pass beyond science towards a synoptic view, correlating with scientific data what may be gained on other rights of way to Reality, then the question arises: Is the scientific picture of Nature and Man in harmony with the religious interpretation reached in other ways, for instance, through the Christian revelation? If not, then there is no 'natural religion,' no 'natural theology.'

(2) The search for a synoptic view has yielded a sketch

rather than a picture, and there are many difficulties and obscurities. Yet we must not fail to appreciate the value of the scientific disclosure of the intelligibility of the world —the order, continuity, unity, and simplicity of Nature.

(3) Another large impression is the practical universality of beauty in Wild Nature, except where there has been recent breakage or where Man has interposed. Among living creatures beauty is almost everywhere except in the half-developed and in parasites—exceptions that seem to prove the rule. Beauty in organisms seems to be the expression of orderly unified living.

(4) There has been in Nature a general advancement in differentiation and integration. The solar system is an advance on the whirling nebula—in differentiation and in its nearer approach to more significant steps, such as the emergence of living creatures. All through the ages life has been slowly but persistently creeping upwards. In the ascent of animals there are discernible trends towards greater mastery of the environment, increased freedom and fulness of life, and a growing dominance of mind.

(5) Progress is a human concept, implying the two preconditions of health and wealth, and then a balanced all-round movement towards the fuller embodiment of the true, the beautiful, and the good. To these there are remarkable correspondences in Animate Nature. For Wild Nature is all for health, and the capitalisation of energy is illustrated both centrally and peripherally. Wild Nature is all for beauty. Success rewards the clear-headed animals that face the facts. A premier place is given to types that are good parents, good lovers, good kin—self-subordinating as well as self-preservative, other-regarding as well as self-assertive. There is an evolutionary momentum behind man at his best; it finds expression in the fibres of his being and in the social system which he develops. The more we know of Animate Nature along these lines, the more does the world become a home in which the religious can breathe freely.

(6) To the question, Does Nature admit of religious interpretation? many would give a *negative* answer. That Nature sometimes shows sanguinary internecine struggle is undeniable. But struggle is a tonic and a sieve; it is not always crude; it is rarely, if ever, 'cruel.' The economy of Nature depends on a series of successive incarnations, and broad foundations are needed to support the soaring superstructure. It is difficult to give a 'reasonable explanation' of 'lost races,' which attain high success and then disappear without leaving any direct descendants. But they may have indirectly served the general advancement of life, and, in any case, we must allow for some freedom of experiment and imagination. Perhaps the possibility of success also implies the possibility of failing to attain to full fruition.

(7) John Stuart Mill arraigned Nature for ruthlessness. But an inexorable world is preferable to a capricious one, and the "friendliness" of not-living Nature to organisms is as conspicuous as her stern sifting. Mill's second accusation was cruelty, but that is mainly an anthropomorphic reproach, and on the other side we have to recognise the abundance of mutual aid, kin-sympathy, and parental care. Mill's third accusation was that Nature seemed to have a grudge against man, and treated him with indiscriminating spite. But this is a somewhat anthropocentric exaggeration of the difficulties that Man has to face in his restless experimenting. The big fact is that Nature's sifting *is* discriminate. Mill concluded that it was irrational and immoral to follow Nature, but his conclusions are as one-sided as his facts. He also concluded that man must work as 'auxiliary' to God in the improvement of a world whose government could not be the work of a Being at once good and omnipotent. As things are, Man's capacity for improving Nature, except by following her method of proving all things, must be regarded with suspicion.

(8) William James arraigned Nature for her hideous-

ness mingled with beauty, her cruelty cheek by jowl with love, her a-morality and meaningless momentum. But he did not discern the great trends of organic evolution.

(9) Huxley exhibited another red picture of Animate Nature—'a vast gladiatorial show,' 'a dismal cockpit,' 'a Hobbesian warfare'; and his advice to man in his ethical endeavours was that he should combat the cosmic process as seen in the struggle for existence. But Huxley interpreted the formula 'struggle for existence' much more narrowly than Darwin; he did not do justice to those forms of the struggle which consist in increasing mutual aid and sociality, parental care, and self-subordination in general.

(10) Our question has been: Is Nature congruent with religious interpretation? We have ventured to answer in the affirmative, partly because of the scientific disclosure of order, unity, simplicity, and advance, partly because of the cumulative suggestion that Nature is Nature with a Purpose, and partly because there are discernible in Nature certain great trends which are in the direction of what man at his best has regarded as Progress. Science itself is a big result suggestive of significance in the long-drawn-out process.

The question why man should be religious at all brings us back to the initial thesis, that religion is the growth of tendrils that reach towards a spiritual order of reality, when man finds himself at his intellectual, practical (ethical chiefly), and emotional limits. That these tendrils simply coil on themselves is a rationalistic interpretation which does not seem to cover the facts. Religion is not merely a projection of the best that is in us; it is an opening of our hearts to the best that is outside of us.

Religion may arise in response to the need for rationalising our experience and finding some answer to the questions—whence, whither, and why, questions which Science cannot answer. It may arise in response to an appeal for ethical aid, from the old "life-givers" up to the Christian conception of 'grace.' Or it may arise in emotional crises,

on the heights of joy and in the depths of sorrow. Or it may be a flower that opens in the atmosphere of Nature Contemplation. In the last case there is in the religious experience something much more than a crutch or a support, there is an enrichment comparable to that afforded by music. This element is present in other forms of religious experience, but it is peculiarly true of that associated with Nature Contemplation.

The chief aim of this book is to show that scientific description in terms of Lowest Common Denominators cannot be in any radical antithesis with transcendental interpretation in terms of the Greatest Common Measure.

APPENDIX

By David Landsborough Thomson, M.A., B.Sc.

I

THE THEORY OF RELATIVITY

In its simplest form, the Theory of Relativity suggests that the laws of motion of classical physics do not adequately describe the properties and relations of moving bodies. But so trivial are the corrections which have to be applied to the older figures, if the theory of relativity be accepted, that they are imperceptibly small, unless in dealing with very rapidly moving objects which can be accurately observed. It is therefore in the science of Astronomy, in the study of the motions of the planets and stars, that relativity has chiefly sought its experimental proof; and it is here, too, that the general scientific and philosophic consequences of the theory are of the greatest importance.

In the study of celestial mechanics the chief factor is the mysterious force known as "gravity," by which two bodies, acting one upon the other, even at a distance and apparently instantaneously, are attracted together. Thus, the earth attracts and is attracted by the sun or the moon or an apple falling from the tree. If the two bodies are small, and especially if they are far apart, their mutual attraction is very slight. Nevertheless, the existence and the position of the outermost planet of our solar system, Neptune, was predicted from the disturbances it caused in the path of the less distant planet Uranus, before its discovery by direct observation; and similar instances could be multiplied. But it should be noted that celestial

mechanics and the Newtonian theory of gravitation assume nothing and tell us nothing of the nature of the empty space between the planets.

Light, on the other hand, undoubtedly travels to us from the sun and the stars *through* space, and any complete theory of light must include or imply a theory of the space in which it is carried. It has long been supposed that light (as well as its kindred radiations, from the long waves of wireless telegraphy to the very short X-rays, which are all similar in kind and travel at the same constant speed) is propagated in the form of electromagnetic waves, vibrating transversely, like the slack of a twitched rope, in an impalpable medium called the "ether." The ether is believed to fill all space and to be material, although quite unlike any form of matter whose properties are known to us; for it is so tenuous that even solid bodies sweep through it without causing the least disturbance or swirl. After all, a block of steel or stone is but a loose network of atoms, and the atoms themselves are spacious solar systems of tiny planets revolving round a minute impenetrable core. The ether of chemistry, a well-known volatile liquid whose inflammable vapour is used as an anæsthetic, must be distinguished from the intangible ether of physics and astronomy, the homogeneous fluid that fills all space and is known to us only in theory as the possible carrier of the waves of light and heat. Sound waves, on the other hand, are carried by the air or by water; they travel much more slowly, and their vibrations are not transverse but longitudinal, so that a sound wave may be compared to an earthworm dragging itself through rough ground—at one place compact, at another stretched out into a taut thread.

Notable among several similar experiments is that of Fizeau, who caused a beam of light to travel in a tube against a current of water. It was found that, although the water refracts and somewhat retards the light, its velocity is not reduced by an amount equal to the speed of the moving water; the reason being that the light travels, not in

the flowing water (as sound waves would), but in the stationary ether. This conception of the ether as stationary is of the greatest importance. The earth moves in an oval orbit round the sun, but the sun and the earth together are moving towards certain of the stars. Or is it that certain stars are moving towards the sun? This question can only find an answer, and indeed can only have a meaning, if there is a something stationary to act as a standard of comparison. The question could readily be answered, then, if the solar system's rate of travel through the stationary ether, its "absolute" motion through absolute space, could be measured. Without the ether-filled space as a stationary standard of reference, only relative motion can be detected: we can never say "moving towards" but only "getting nearer."

But when, as was only natural, scientists set out to prove and to measure this absolute motion, the results of the experiments were extremely puzzling. The famous experiment of Michelson and Morley was intended to show that the earth actually was rushing through a stationary, light-carrying ether. The idea was that if a beam of light travels through the ether in the same direction as the earth does, to an observer on the moving earth the light will seem to be slower than when it is going in the opposite direction. The first case may be compared to a slow train being overtaken by a fast one, and the second to the shattering rush of two trains passing in different directions. But although the experiment was conducted with the most refined accuracy, the surprising result was that no "fast" and no "slow" directions could be found. There was no sign at all that the earth was moving through an ether. Somewhat similar was the result of a quite different experiment by Trouton and Noble; this was founded on a classical demonstration due to Rowlands, who showed that if electrically charged condensers were moved along mechanically, for example on a wheel, they exerted a magnetic action like that of a real flowing current of electricity;

in the new arrangement, the mechanical motion was to be supplied to the condenser simply by the earth's rush through the ether; but here again no sign of this rush was to be found. It seemed necessary to abandon the convenient idea of the ether altogether.

But this evil day was put off by a theory due to Lorentz, which successfully explained the first and more important of these two experiments, and many other facts besides. The suggestion was that any object moving through the ether became shortened in the direction of its motion. Such a shortening could not be measured directly, since the standard of length, be it ruler, micrometer, or what not, would undergo the same contraction. Lorentz went further and set up a series of equations by means of which this shortening could be calculated in terms of the velocity of the object and the speed of light.

Einstein's first great contribution to the subject lay in his deriving these same equations from much more fundamental arguments—arguments which attacked certain prejudices about the nature of Time which lay very deep in the foundations of both every-day and of scientific thought. These arguments have been illustrated by a large number of imaginary experiments. If, for example, an observer is watching a clock which is rapidly receding from him (or if he is moving away from the clock, which comes to the same thing), at each second the light waves by which he sees the clock will have further to come, and take longer time on the journey; so that the clock will appear to him to go slow. In fact, to a stationary observer, time on a moving clock will appear longer than when the observer and the clock remain the same distance apart. Einstein insists on the point that a stationary observer is not in any sense wrong in supposing that the receding clock goes slow, any more than an observer moving along with the clock would be wrong in saying that it kept good time throughout. Both views are equally correct; it all depends on the point of view; it is only by convention

that we regard the one more than the other as the "real" speed of the clock. In the same way a stone thrown out of the window of a railway carriage (horrible crime!) will seem to the passengers to fall backwards; but a plate-layer will see it fall forwards, though not as fast as the train. Neither of these, in the absence of an absolute space to use as a standard of reference, has any claim to be regarded as the one and only "real" path of the stone. That this is always so, follows from one of the essential clauses of the theory, that the velocity of light is constant, irrespective of any motion of the observer.

The fact of the connection between the slowing-down or "dilatation" of time, the velocity of the clock, and the speed of light, is perfectly plain, a mere matter of common sense, although in actual figures Einstein's answer is not quite the same as the common-sense one. It is less easy to realise intuitively that a moving body will seem to a stationary observer to be shortened in the direction of its motion, though the argument is almost the same. Let us remind ourselves that time is always measured in terms of length, as a *distance travelled* by the hand of a clock, or a planet, or the shadow of a sun-dial, or the flame of King Alfred's candle; even the molecules of our bodies are natural clocks. Lengths may also occasionally be measured in terms of time; the distances between the stars are conveniently counted in "light-years," each of which is the distance travelled by light in one year. Relativity asserts, too, that "when" has no meaning unless "where" be added; the two are closely connected.

The amount of shortening of a moving body, as calculated from the principle of relativity, is the same as that calculated by Lorentz from his theory of "electronic contraction"; but it is now founded on a much firmer and more deep-rooted basis. No longer an unexplained property of matter, it stands revealed as the inevitable consequence of our mode of perception and knowledge of distance and of movement. In the same way, the slowing-

down of the receding clock is not a pernicious weakness of clocks in general, but is imposed upon us as a result of the only way in which we can be quantitatively aware of time. These ideas, moreover, are now freed from the conception of an absolute space filled with a stationary ether, which is still essential to Lorentz's theory. The abandonment of the idea of a single absolute or public "real" time is at once the immediate result and the best justification of the surrender of the cherished notion of absolute space. It is now more correct to say that every object, or every group of objects that share the same motion, has its own space and its own time: it is only for convenience that we regard some of these as more important than others.

The relation of calculations based on the theory of relativity to those previously accepted may be summed up in a few words: the velocity of light is now included in the calculation, instead of being assumed to be infinitely great. The exact relation is most plainly defined by the simple algebraic expression for the shortened length of a yardstick moving with velocity V:

$$\sqrt{1-\frac{V^2}{C^2}}$$

where C is the speed of light. If this speed were infinitely great, it is clear that the length would remain unchanged, as the subtracted fraction would be zero. But the speed of light actually is so great (one hundred and eighty-six thousand miles per second) that no perceptible alteration to the calculations takes place, unless the velocity of the moving body be very great. It also follows from this expression that no real body can ever attain the velocity of light; for this would reduce its length to nothing. The greatest known velocities are those of certain particles (electrons) shot out of the atom of radium and kindred elements in the strange decay or explosion called radioactivity; these may attain a velocity nine-tenths that of light—but this is quite exceptional.

The theory of relativity also asserts that the mass or weight of a body is increased, if the body is set in motion, in a ratio comparable to those discussed above. This idea may be viewed from another angle: if giving a body energy of motion also gives it increased mass, then it may fairly be said that the energy of motion has a mass of its own, which is inseparable from it; and this, the theory asserts, is equally true of all other kinds of energy. So novel are these ideas to physics that their experimental proof, which has now been accomplished, is considered to be the decisive point in the proving of the special theory of relativity.

Experimental evidence and concrete applications of relativity are only to be found where accurate observations of the motion of fast-travelling bodies can be made. In Astronomy, which offers the finest opportunities for accurate work of this kind, the special theory outlined above is of restricted application, inasmuch as it deals only with uniform motion in straight lines. This difficulty somewhat delayed the development of the theory, which indeed awaited the growth of a new science in which it might play a part. Such a science was found in modern sub-atomic physics, which was made accessible to relativity by the brilliant theoretical work of Niels Bohr of Copenhagen, and by the strange paradox that the most accurate of observations can be made of the minute constituents of atoms themselves ten thousand times smaller than the tiniest particles discernible in the microscope!

Chemical and physical theory throughout the nineteenth century had at every turn reaffirmed the existence of *atoms*, as the smallest conceivable particles in which a chemical element could exist while retaining its identity. Elements of the Radium family, which became known about 1898, have overcrowded atoms that break up, with the emission of various rays and particles and the production of a new and lighter element by a natural and unalterable process of transmutation; and this discovery led

to the conception of the atom as a complex structure, chemically indivisible. Bohr supposed that atoms were "solar systems," in which minute particles of negative electricity, called "electrons," revolved at a relatively great distance round a small but heavy central core or nucleus. In the simplest of all, the atom of hydrogen, the nucleus is of uniform structure and unit weight, and there is but one planetary electron. It has been assumed, although it contradicts experience in other fields, that the electron's normal revolving motion is uniform and not accompanied by either absorption or emission of energy of any sort. But unlike the moon, which remains at a fixed distance from the earth, the electronic satellite is able to move outwards to other and more distant orbits if energy be supplied to it in the form of light or heat. The electron may subsequently return at a jump to its original path, and in doing so will radiate afresh as much energy as it absorbed in moving outwards. This energy takes the form of light, although it may be invisible to our eyes, and the frequency of vibration, or "colour," of the light will be determined by the distance jumped by the electron from orbit to orbit. These frequencies can be measured with the finest degree of accuracy by the use of the spectroscope, and from them may be calculated the size of the orbits in which the electron can travel. For it follows from the modern "Quantum Theory" (see Appendix II) that there are "smallest-possible" amounts of light, which we might call light-atoms or, better, light-quanta; and from this it follows that the orbits in which an electron may travel are not innumerable, but restricted to a definite "family" all closely related: we may call them the "one-quantum," "two-quantum," and so on. Sommerfeld has extended this idea by his suggestion that there may be orbits of the same size and energy value; that is to say, the same quantum number but of different shapes, some being more oval and others more circular. When the theory of relativity is applied to this new de-

velopment, it transpires that in the more oval orbits the electron moves with varying speeds and, therefore, as we have seen, with varying mass. This betrays itself as a slight splitting of the line of light seen in the spectroscope into a "fine-structure" of many lines, which is found to agree so well with the calculated results that the special theory of relativity may be said to be proved by this alone.

Another sub-atomic application of the theory of relativity shakes our belief that two and two always make four. The nucleus of the atom of helium, the second lightest known, is believed to consist of four hydrogen-atom nuclei closely bound together. But the puzzling thing is that the weight of the helium atom is rather *less* than that of four hydrogen atoms. It is supposed that the union of four in the helium nucleus is a very stable arrangement of the units, with very little energy; while the four units considered separately have more energy, and therefore, as we have seen, they must and do have greater mass. It is known that the nucleus of the large atom of radium contains hydrogen nuclei united in these groups of four, which are shot out when the atom explodes and are called alpha-particles. It is also known that no earthly power would suffice to tear apart this stable union of four individuals, even if great force could somehow or other be brought to bear upon them.

In spite of its somewhat restricted field of application, the Special Theory of Relativity was too important to be ignored in philosophy and was utilised by Minkowski in his picture of the universe, in which relativistic motion was to reign supreme. This picture was based on the idea that the universe possessed four dimensions, "length, breadth, height," and *time.* Although it is impossible for us to visualise such a thing, it is possible to treat mathematically the conception of time as a dimension perpendicular to the other three as they are perpendicular to each other. In such a universe an event, occupying but an instant of time and concerning only a single point

in space, would be represented by a point. But a particle would be represented by a continuous line in the time direction, representing its whole history, past, present, and future, and constantly curving in this direction or in that as the particle changed its position in space; such a line Minkowski called a "world-line." He found it convenient to imagine that even in empty space there exists a perceptible "substance" (avoiding the fatal word "ether"), and every particle of this, as well as every particle of matter and of electricity, has its own world-line. The sum of all these world-lines taken together and completely, in the four dimensions, forms our universe: not only as it exists at any moment, but also and equally its whole past and its whole future. It is clear that the entirety of this grandiose conception is based on the close relation shown by relativity to exist between space and time; in Minkowski's own words, "from this time forth space and time in themselves are to become mere shadows, and only the union between the two is to preserve independent existence." In such a world, light behaves curiously, its velocity resembling both zero and infinity; this is due to its movement in time "cancelling out" its movement in space.

Meanwhile, however, Einstein was patiently working out a General Theory of Relativity, which should hold good for every sort of motion, including rotation and acceleration, and not merely for uniform motion. When this was given to the world, it became clear that Minkowski's picture was incomplete. It had been considered possible in theory to determine the position of any event-point in space-time by four measurements or "co-ordinates" of length, breadth, height, and time, each "at right angles" to the other three; just as the position of a mark on a flat sheet of squared paper can be determined by two measurements or co-ordinates at right angles to each other. On an irregular or hummocky "non-Euclidean" surface this is no longer possible; but more than seventy years ago Gauss had shown how arbitrary curving lines might in such a

case replace the rectilinear co-ordinates for the purposes of measurement; and the great mathematician Riemann showed that the idea of Gauss's co-ordinates could equally well be applied to systems of three or four dimensions. Einstein succeeded, in his general theory of relativity, in applying the abstract work of Gauss and Riemann to the four-dimensional non-Euclidean universe. We can now no longer define an event-point in the universe by three "straight" measurements of space and one of time, but rather by four "curved" measurements each of which contains the elements of space and time. Summed up in a sentence, the general theory of relativity states that the fundamental laws of nature will hold good in any arbitrarily chosen set of four-dimensional Gaussian co-ordinates.

So much tangling of the skein requires some justification, and this is found in the *Theory of Gravitation* which follows from the general theory of relativity. It is based on the idea that the presence of material bodies, especially massive ones, causes a warping or distorting of the four dimensions of the surrounding space, somewhat in the same way as a weight distorts the surface of an india-rubber balloon on which it rests. It is impossible to explain the full beauty of this hypothesis without the aid of the most abstruse mathematics; it may be shortly said that the presence of a field of gravitational energy involves a change over from one set of Gaussian co-ordinates to another, in a manner made mathematically intelligible by the general theory of relativity.

Some of the consequences of the theory are nevertheless understandable enough. At a stroke it gets rid of the mysterious old hocus-pocus of "action at a distance" which gravity was supposed to exert. As Professor Eddington has said, we need no longer speak of the earth as being attracted by the sun, but rather of the earth as trying to find a way through a time and space *tangled up* by the presence of the sun. The new point of view fur-

nished at last a beautiful mathematical explanation of the behaviour of the planet Mercury, which, it has long been known, never treads exactly the same path twice. Again, we should expect that even the fast-travelling rays of light would be deflected in traversing a tangled space; and when, during an eclipse of the sun on May 29, 1919, a British expedition in Brazil showed that light from distant stars actually was deflected when it passed near the sun, and to the extent calculated by Einstein, the general theory of relativity was looked on as more than probably correct. This occasion marked the birth of a great popular interest in relativity, due in part to the remarkable philosophic content of the theories, and in part to the impressiveness of the intellectual monument which they form.

For it must be realised that the four-dimensional warping produced by matter is something that defies the imagination. We can think of a warped surface, but we cannot translate this idea into terms of three dimensions, much less four, and are certain to fall into error if we try. Yet to mathematics this abstraction presents no insuperable difficulty and problems of great complexity can be worked out. For instance, it follows from the theory that the universe is a closed curve, that it is endless, boundless, yet of definite size. A circle is an endless line, yet of definite size, and the surface of a perfectly definite sphere is without limits in any direction. The universe is a comparable system in four dimensions, which we can conceive of only by analogy. This is due, roughly speaking, to an averaging-out of the warpings produced by matter. By estimating the average density of matter throughout the universe (an inconceivably low figure, far below that of the highest vacuum ever produced in a laboratory), the size of the four-dimensional universe can be roughly calculated. The Dutch astronomer De Sitter finds that its circumference is one hundred million light-years; a light-year is over five million million miles, and the sun is only eight-and-a-half light-*minutes* from the earth. Incredible, unimaginable ex-

panse! Yet the faintest and farthest nebulæ known to astronomers are perhaps one-tenth of that distance away. Let us, however, remember that we are dealing with four dimensions, and firmly resist the temptation to wonder "what lies outside." We can never, even in imagination, even by mathematics, come to the limits of our universe; as far as all within it is concerned, it is endless and boundless in every direction of space and time.

II

ATOMICITY AND THE QUANTUM THEORY

THE idea that matter is not continuous but discrete, that any process of subdivision, carried to whatever lengths, will eventually be confronted by indivisible particles or atoms, dates from ancient Greek philosophy. It was discussed by the founders of modern chemistry, but awaited the coming of John Dalton, who, in the first decade of the nineteenth century, threw a new light on the question, which he approached from the point of view of the Principle of Constant Combining Weights. This asserts, for instance, that the weight of oxygen which combines with a given weight of hydrogen to form water is always the same; and the conclusion drawn is that the weights of the atoms of oxygen and hydrogen are in the ratio of these two combining weights. But the work of Avogadro on gases showed that this new atomic theory was not in all respects the same as earlier ones, and introduced into science the idea of the "molecule." The molecule of a chemical element may be a single atom, or a group of two or more precisely similar atoms united together; the molecule of a compound will contain atoms of each of the constituent elements. Thus, the molecule of water contains *two* atoms of hydrogen and one of oxygen; wherefore the conclusion come to above about the relative weights of the oxygen and hydrogen atoms is not correct; the hydrogen atom weighs only half as much as that experiment suggests at the first glance. Oxygen combines with two atoms of hydrogen to form water, nitrogen with three to form ammonia, carbon with four to form marsh-gas, or fire-damp; these different combining powers are called the "valencies" of the elements.

Faraday's study of electrolysis led Helmholtz and Stoney independently to the conclusion that the idea of atoms of matter necessarily involved the idea of atoms of electricity. It is now known that if a salt such as sodium chloride be dissolved in water, the molecules break up, and positively charged atoms of sodium and negatively charged atoms of chlorine exist in the solution. If an electric current is passed through, the free charged atoms, or "ions," will migrate to the two poles and give up their electricity. At the positive pole the chlorine will escape as a gas, at the negative pole the sodium may be dissolved in mercury. Faraday showed that the amounts of sodium and chlorine obtained were in the ratio of their atomic or combining weights. From this it followed that the electric charges carried by the atoms were all the same in amount, whether positive or negative, and were in fact to be regarded as "atoms" or "unit charges" of electricity.

These atoms of electricity, made known in this way, were simply the charges attached to individual atoms (or, rather, "ions") of matter; but while this is always true of positive electricity, it is not always true of negative electricity, detached particles of which, smaller and lighter than the smallest particles or atoms of matter, can and do exist in a free state. In an ordinary X-ray bulb, when the electric current is passed through, streams of these particles of negative electricity, or "electrons," start out from the cathode (where the negative current enters the bulb). At the same time atoms of matter, charged with positive electricity, pass through the cathode in the other direction. The inference is that the negative electrons form a part of the neutral atom, and when some are set free to form cathode rays, the atom is naturally left with a positive charge. In some materials all the electrons are closely bound to their atoms, and these materials can be used as insulators; but in others there are free electrons which may wander and carry an electric current through the substance, which becomes a conductor. It is chiefly to Sir

J. J. Thomson that we owe our knowledge of the nature and properties of the electron.

As long ago as 1903, Lenard found that the electrons of cathode rays could penetrate through thin sheets of metal; the stream of infinitesimal bullets encountered not a wall but a fence, and if the metal was one with heavy atoms, the fence was one with thicker bars than in the case of lighter metals. Since the atoms of a metal are set rather close together, the conclusion was that the electrons could fly freely *through* the atoms, but not through an impenetrable central core. The analogy of a comet flying through the solar system without disturbing the planets was too obvious to be missed. Moreover, in 1913 Rutherford and others made a similar discovery when using a larger and more readily watched projectile—the positively charged alpha-particles emitted by radium. These for the most part traversed metal sheets with but little deviation from the straight path, though always slightly deflected by the attraction of the negative electrons of the metal atoms. But a few of the particles passed close to the central cores of these atoms, and were sharply repelled by the positive charges which these cores appeared to carry, so that they were turned off at a sharp angle. Measurements of these deflections made it possible to estimate both the size and the amount of the positive charge of the central cores of various atoms. It turned out that the amount of this positive charge was always equal to the number of the element's place in the list running from hydrogen, the lightest, number one, to uranium, the heaviest, number ninety-two. The picture of the atom that gained acceptance was that of a solar system: in the centre lies a positively charged core in which is concentrated the weight of the atom, while at great distances around this core there circle the negative electrons. The atom is neutral, and therefore the number of electrons must always be the same as the number of positive charges on the nucleus and as the "atomic number"

of the element. The next step forward depended on the idea of the atomicity of energy, and this is the central idea of the Quantum Theory.

Something has already been said, in the first section of this appendix, in regard to the modern theory of light, that it is a transverse vibration in a hypothetical medium called the "ether." Such a vibration is characterised by the wave-length or distance between the crests of two succeeding waves, the opposite of which is the "frequency" or number of waves in a given time, or, what is much the same thing, in a given distance. Clerk Maxwell surmised that light was an alternating electro-magnetic field, whose source was an electrically charged particle moving in a non-uniform manner. Since the days of Heinrich Hertz it has been practicable by purely electrical means to send out into space "wireless" waves which differ from light only in their much greater wave-length or smaller frequency. Their wave-length varies from several miles to a few metres. After these come a series of infra-red rays, which lead through heat rays to those of red light. Shorter than violet light are the ultra-violet rays which affect a photographic plate, and shorter than these the X-rays or Röntgen rays set up by the impact of the cathode-ray electrons on a suitable metallic target in the wall of the X-ray tube. Such short waves have, as we know, a much greater "hardness" or power of penetration through solid bodies than ordinary light; yet all these various radiations are akin, and differ only in wave-length and frequency; all travel with the same velocity. Between the shortest wireless waves and the shortest known rays of the X-ray group is a distance of some thirty octaves, of which one alone is visible to our eyes as light and ranges through all the colours of the rainbow from red, through yellow, green, and blue, to violet.

The quantum theory was first stated in 1900 by Professor Max Planck, in his investigation of the radiation of light-waves from a heated body. Such a radiation may be

described as a transference of energy from the atoms of matter to the ether; and the quantum theory asserts that all such transferences take place not continuously but step by step, the minimum and uniform size of a step being termed the quantum of action (instead of quantum we might, figuratively, say "atom"), which is known throughout physics by the symbol h. This unit amount of work might be expressed as a fraction of the work done by a one-horsepower engine in one minute; but to convert the one into the other, it would have to be multiplied by a figure of two, followed by forty 0's! This theory of action taking place in little "jerks" immediately cleared up several points in the study of radiation, to solve which its assistance was first invoked, and also yielded good numerical value for the size of the hydrogen atom and the magnitude of the unit charge of electricity. Einstein and others also applied it to the study of the atomic heat of bodies, and it was also Einstein who initiated the most striking development of the theory by extending it to light and declaring that light was also made up of units or quanta. This idea found application in the study of the "photo-electric effect," which may be briefly described as follows: a metal plate on which impinge light rays of short wave-length will shoot out negative electrons into the air and, therefore, become positively charged. If the light is dim, only a few electrons are set free; but no matter how dim the light, such electrons as are set free will all travel with the same speed, not one whit slower than in a bright light. To change the speed of the escaping electrons we must change the "colour" or frequency of the light. This is a very puzzling fact, and not to be explained by anything that was previously known about light. It may be compared to a bombardment by heavy artillery, representing the light: if there are few guns, there will be fewer explosions, but each explosion will be just as powerful and send the splinters flying just as far as if there were twice as many shells arriving. To change the character of the

explosions we must bring up larger or smaller guns. The inevitable conclusion is that the light arrives in "atoms" or "parcels" or *quanta*, which may be compared to the shells. It should be noticed that the "light-quantum" is a unit of energy, not of work, and that its size depends on the "colour" of the light: it is, in fact, h times the frequency of the light. Hence the "parcels" of light of short wave-length and high frequency, such as X-rays, are by far the most powerful. It is plain that this idea of light-quanta is far removed from the old view of light as a continuous vibration in a continuous "ether"; but no one knows how to reconcile the two views.

Let us now return to our picture of the atom as a solar system, and attempt to translate the "photo-electric effect" into its terms. What happens is plain enough: the energy carried to the atoms of the metal plate by the impinging light causes some of the planet electrons to move outwards, out of reach of the electrical attraction which the nucleus of the atom exerts, and free to wander into the air. But if the impinging light is one whose quanta are on the small side, they may not be strong enough to do all this; they will merely move the electrons of the atoms a little outwards from the nucleus, not far enough nor fast enough to break their electric bonds. The atom is now in an energy-charged state, with an electron further from the nucleus than need be, and comparable to a wound-up clockwork toy. At the first chance the clockwork will run out, the electron will return towards the nucleus to its old position: but in doing this it will give back to the ether the energy it has just got from it; that is to say, it will radiate light.

It seems at first sight as though the electrons might revolve round the nucleus at any distance they "pleased," and move outwards or inwards to any extent. But the quantum theory, unlike the older theory of light, tells us that that is not so: the light energy that is absorbed or emitted comes in discrete amounts or quanta; there cannot

then be a continuous series of possible orbits in which the electron may travel. Out of the continuous manifold of possible orbits, the quantum theory selects a family of "favoured" orbits, on which alone the electron may travel; and a simple numerical relation connects these orbits. We may speak of them as the "one-quantum," "two-quantum," and so on: there are no fractions. The quantum in this case is the "moment of momentum," or the mass of the electron multiplied by its speed multiplied by the radius of its orbit.

We may now turn back for a moment to discuss what has long been known about the spectrum of hydrogen. Hydrogen in the electric arc emits light, which, when examined through the spectroscope, is revealed as a series of lines of definite and characteristic wave-length. These lines are wide apart at the red end of the spectrum and closely packed at the violet end; there are other and similar series, more recently discovered, in the ultra-violet and infra-red regions of the spectrum. Forty years ago, a formula was discovered by Balmer from which could be calculated the wave-lengths of all the kinds of light that hydrogen can emit. It is one of the great triumphs of Bohr's theory of spectra and of the atom that it yielded the same accurate formula from purely theoretical considerations. The atom of hydrogen is the simplest possible atom: it consists of a nucleus of unit weight and unit charge, round which circles one electron. If the atom has been "wound-up" by light or heat, the electron may jump downwards into the innermost orbit, and in doing so emit light: this light will be in the ultra-violet series, and its exact wave-length will depend on the distance the electron has come: there are as many possible distances, as many possible orbits, as there are lines in that series of the spectrum. If the electron does not reach the innermost orbit, but only the second one, the light emitted will be of the second or visible series; and so on. All this is simple enough, but two difficult points must be kept in mind: all

the time the electron is circling in its orbit, at a speed of one thousand five hundred miles per second, it is neither giving energy to nor receiving energy from the ether; it is as if it were stationary: and secondly, the jump from orbit to orbit appears to be truly instantaneous, to occupy literally *no* time at all.

Bohr's theory of the atom and of spectra, outlined in the last three paragraphs, has been explored and extended in every direction, with the most fruitful results and with triumphant experimental confirmation at every step: it has given to the science the power of prediction. Sommerfeld, one of its most brilliant exponents, has extended the idea of circular orbits for the electron to include possible oval orbits, and the application of the theory of relativity to this development has been already discussed (Appendix I). A revolving electron may be regarded as a circular current of electricity, and may be assumed to possess a *magnetic* moment, which will be a unit, or "atom," of magnetism: here again experiment has confirmed the value calculated for the amount of this unit, or "magneton."

But of all the outcomes of the theory none is more surprising than Bohr's "Principle of Correspondence" between the old wave theory of light and the new quantum theory. We have already spoken of the apparent incompatibility of these theories. It is possible, however, to imagine an atom with an electron travelling in some infinitely large orbit, such that the light emitted will be the same, whether calculated from the old theory (the light's frequency being determined by the speed of rotation of the electron) or from the new. This case is, most probably, never realised in fact. The older theory allows us to make certain calculations of the brightness and behaviour of the light emitted which the new theory, in spite of all its virtues, does not; but what is the good of that, in an imaginary case? But the principle of correspondence makes the remarkable assertion that this interchange of theories, which is perfectly justifiable in the imaginary case, will

be reasonably valid in every possible case. What is even more surprising is that calculations based on this assumption agree excellently both with experiment and with the incomplete theoretical work in the same direction based on pure quantum theory. So it appears that we may use the one theory to help out the other where it gets into difficulties! The conclusion is forced upon us, that the old and new views of light do not contradict each other, but merely extend in different directions: though how this may be we do not know. It is like seeing the same scenery from very different view-points.

Turning now from physics to chemistry, we find that the Bohr theory has still something to say. If the atom of hydrogen loses its single electron, it becomes a positively charged "ion," and is eager to enter into combination with a negative ion which has one electron too many. An oxygen ion must be regarded as having two electrons too many, so that it combines with two atoms of hydrogen to form a molecule of water. Of the exact nature of the union between atoms the theory tells us very little.

The next element in the series, after hydrogen, is helium, with two electrons; and this seems to be a very stable arrangement, for helium never combines with any other element. Lithium has three electrons, but two of them form an inner "shell" like the two electrons of helium, while the third lies further from the nucleus in a "shell" of its own. As we go up the list, more and more electrons are added into this outer shell until at last there are eight, and this again is a very stable arrangement, and one which other atoms try to imitate. Oxygen, for instance, has six outer electrons and readily takes up two extra ones to form a complete shell of eight: this makes a doubly negative ion of the atom, one ready, as we have seen, to combine with two positive hydrogen ions. Moreover, when the shell of eight electrons is complete (in the gas Neon), succeeding elements have to build up a third, outermost, shell, which is also complete when it contains eight elec-

trons. This process, with certain modifications and rebuildings of the inner shells, goes on right up to the heaviest of the elements, Uranium, with ninety-two electrons. It turns out that elements with a different number of shells but with the same number of electrons in the outermost shell (for example, Lithium, and Sodium, the next in order to Neon) are closely alike in many ways. They are chemically alike: they resemble each other in their malleability, compressibility, melting-point, and many other properties: their spectra, which are determined by the movements of the single outermost electron, are complex but similar in general structure. All these are called peripheral or external properties of the atom; and long before such pictures of the atom were imagined, these similar elements had been grouped together in Mendeléef's Periodic Table of the Elements.

What do we know of the inner shells of large atoms? Only this: that their electrons still have the power of moving inwards and outwards to some extent, and in doing so they emit light; but this is no longer visible, it is X-ray or short wave-length light. The exact frequency of the "X-ray spectrum" depends directly on the positive charge or attractive power of the nucleus of the atom, which is the same as the atomic number of the element. This discovery, which makes the X-ray spectrum of an element a property by which it can very easily be detected, is due to Moseley, an English investigator of the first rank, who was killed at Gallipoli. It should be noted here that while the idea of inner and outer "shells" in which the orbits of the electrons lie is a very convenient one for classification, and while there may be an averaging-out into separate layers or shells, there is actually a great deal of interlacing of orbits.

What do we know of the heart of the atom? Till a few years ago we knew nothing except what the nucleus itself told us. Certain heavy elements, such as uranium and radium, have overcrowded nuclei, from which burst

forth beta-rays or electrons, and at other times alpha-particles, which are neither more nor less than atomic nuclei of the element helium. It seems that the nucleus of helium is made up of two hydrogen-atom nuclei, each of which is supplied with an electron, and two hydrogen nuclei without electrons, whose positive charge is neutralised by the two outer or planetary revolving electrons of the helium atom. We may compare this to two boxes with their lids fixed on, and two whose lids are set apart and represent the planet electrons. The nuclei of all the ninety-two elements are probably made up of hydrogen nuclei, of which there are in uranium two hundred and thirty-eight (the atomic weight of the element), but only ninety-two of these "have no lids on" and are neutralised by ninety-two outer, revolving electrons. Uranium is the last and ninety-second element of the list. These views have been substantiated by a very important experiment made by Sir Ernest Rutherford, who bombarded nitrogen atoms with alpha-particles from radium, and succeeded in "blowing up" the nuclei and obtaining recognisable hydrogen nuclei from them. The atoms of all elements, then, are made up of nuclei containing a large number of hydrogen nuclei or protons and a smaller number of electrons; the rest of the electrons revolve around and outside the nucleus or "sun." Elements which, having the same number of "open boxes," have the same properties, but have different numbers of "closed boxes" and therefore different weights, are called "isotopes."

A note may be added on the actual dimensions of atoms. The smallest particles visible with the naked eye are about one-tenth of a millimetre in diameter. The microscope reveals particles one hundred times smaller. Two hundred times smaller still are the large molecules of starch, whose presence gives, not a milkiness, but a slight opalescence to water. An atom of hydrogen is one hundred times smaller than these. But the nucleus or the electron is only one-millionth of the size of the atom! It is, perhaps, better

to avoid speaking of the size of the electron, for it is so minute that the conception of size has quite lost its meaning. As for weight, according to most calculations the hydrogen atom weighs one and a half times the million million million millionth part of a gram; and the electron weighs little more than one two-thousandth part of this!

III

STATES OF MATTER

THE atom has become much more real to us in the last twenty years. Photographs have been taken of the paths of individual atoms and even electrons flying through an atmosphere of saturated steam, which condenses in their wake. Several little scientific toys enable any one to watch the explosions of atoms of radium moment by moment. Sir Ernest Rutherford has smashed open the very heart of the atom of many different elements. Most important of all, Bohr's generalisations have opened a doorway through which the search-light of mathematical reasoning can play. The idea of "atomicity" has never been more fortunate in its protagonists than it is to-day. But it is well to remember that, long before the dawn of this new epoch in physics, much had already been discovered about the atom: its size and weight had been estimated with reasonable accuracy. The older method of approach, however, was entirely different; for the atom could only be regarded either as a mere constant proportion in chemical combinations, or as a fraction of the molecule. Our knowledge of the molecule is descended in lineal succession from the work of Avogadro in 1811, which led presently to the kinetic theory of gases.

Several isolated observations on the behaviour of gases are united in the convenient form of the "gas equation," which links together the pressure a gas exerts with the volume which it occupies, its temperature, and the number of molecules in the weight considered. It is to Avogadro that we owe the idea that even where the gas is a chemical element whose atoms are all alike, they may be united in pairs or in groups called "molecules." Equal volumes of

all gases at the same temperature and pressure contain equal numbers of molecules; this is Avogadro's hypothesis. The molecule of an element has a complex spectrum, quite distinct from the spectra of the atom considered above, but probably ruled by quite parallel laws.

The "kinetic theory" assumes that the molecules of a gas are in rapid perpetual motion in straight lines. At ordinary pressures, in the atmosphere for example, they are not at all closely packed together; but even so a molecule does not get very far before it collides with another—on an average, it travels about twenty times its own length, or a millionth of a centimetre, between two collisions. The molecules travel a quarter of a mile in a second (rather faster than sound), and in this distance and this time each of them suffers five thousand million collisions! It is an essential part of the theory that these collisions are perfectly elastic, the molecules rebound with no loss of speed, no energy is wasted as heat or otherwise. The pressure which a gas exerts on any object, for instance upon the walls of a containing vessel, is due to the continual impact of flying molecules; if the temperature is raised, the molecules travel faster than ever and there are more impacts. All the known properties of gases can be explained in terms of this theory of their nature, of which Democritus and Lucretius had an inkling, but which was mathematically expressed by Joule, Clausius, and Clerk Maxwell between 1850 and 1860.

Let us now imagine an experiment which consists in compressing a certain volume of gas. As the volume diminishes, the pressure must rise, for there will be more impacts on the containing walls. A time will come when we can no longer disregard, in the gas equation, the volume occupied by the incompressible molecules themselves, and the gravitational attraction which they exert upon each other; at ordinary pressures these are trivial factors. The experiment may be helped on by cooling, which slows down the movement of the molecules. At last we will find the

molecules tending to cluster into little groups, tending to form a close-packed film around the walls. *In other words, the gas condenses and becomes a liquid.*

Within the liquid there is still a continual rushing to and fro of molecules, but they are now much more tightly packed, and a liquid is almost incompressible. At the surface, molecules continually break free and invade the space above, but others return again to the liquid; a balance is maintained between evaporation and condensation. The properties of liquids are not so simple and not so readily interpreted in terms of molecules as those of gases, with one important exception, the property of surface tension. It is surface tension which allows us to float a dry needle on water, which draws water up through the pores of a lump of sugar, which makes the water rise a little where it meets the side of the cup, which makes soap-bubbles and the droplets of mist spherical; it is of vast importance in the life of the living cell. This surface tension may be roughly described in a phrase: the molecules which actually form the surface hold more tightly to their colleagues than to the molecules in the body of water below; they form a "skin" which is not easily broken, because it is always trying to reduce its own area.

The change from liquid to solid is not unlike that from gas into liquid: it is nearly always accompanied by a reduction of volume. It may, however, take place in different ways: the jostling crowd of molecules may be stopped in a flash, higgledy-piggledy, by the Medusa's head of sudden cold; the resulting solid is a *glass*. But the true type of solid is crystalline, and the crystal is not a disordered mob of molecules, or atoms, but a regiment ranked and filed. That the explanation of the characteristic angular form and complex optical symmetry of crystals was to be found in an orderly arrangement of their units of structure was a favourite idea with mineralogists. The experimental proof is due largely to Sir W. H. and Professor W. L. Bragg, who followed up a discovery of von Laue's, that

X-rays could be used to investigate crystal structure. Ordinary light is too coarse an instrument: the short-wave X-ray is a finer probe. The converse to the work of the Braggs was supplied by Moseley's investigation of unknown X-ray spectra by means of known crystals.

X-ray analysis distinguishes three types of crystals. The first type reigns supreme in organic chemistry, and its units of structure are *molecules* and are all alike. But the bonds between the molecules, whatever their nature, are not very strong; such crystals have a loose, lattice-like structure, they are not very hard and are easily melted by heat. The second type is exemplified by the diamond. Here the units of structure, still all alike, are *atoms* of carbon: each has four neighbours, with each of which it probably shares a pair of electrons. This, it appears, is a very strong bond, for the diamond is the hardest substance known, and very refractory; the atoms of carbon may be differently arranged, however, and form soft, slippery crystals of opaque graphite. The third type of crystal is typical of inorganic salts, and common salt, sodium chloride, is an excellent example. Here the units of structure are electrically charged atoms or ions. Each positive ion of sodium is surrounded by six negative ions of chlorine: above, below, in front, behind, to right, and to left, all equidistant and arranged in cubical order: each chlorine ion is likewise surrounded by six ions of sodium. There is no molecule consisting of one atom of sodium and one of chlorine (these occur in solution in water, but here too they tend to break up into ions); the whole crystal is a huge molecule. Crystals of salt are built upon a cubical plan, but other salts take up oblong or rhombohedral or other positions, and may betray the fact in various properties of the crystal: the interference with beams of light, the hardness, the conduction of heat and electricity, the rapidity of dissolution may all be different in different directions in the crystal.

Hitherto we have spoken as though the atoms of a solid

were motionless, which is by no means the case. They do not travel and collide, it is true, and they are firmly fixed in certain positions; but within a limited range they are capable of rapid vibration. It seems that the atoms of every substance have a characteristic frequency of vibration, which they "prefer." This factor enters into studies of the "atomic heats" of bodies, for different elements differ in their ability to take up heat; and this is a question where the aid of the quantum theory has been successfully invoked. The solid, moreover, reflects most strongly light that vibrates at the characteristic frequency of the substance; but if the light passes *through* the solid, it will absorb the rays of its own favourite frequency and allow the rest to pass. A translucent copper film reflects red, but it also absorbs red, and allows only green rays to pass through it.

So far we have considered only pure chemical elements and their compounds; coarse mixtures, such as emulsions of oil and water, or suspensions of mud in water, or mixtures of sugar and sand, need not detain us; but the study of true solutions demands attention. The molecules of gases always interpenetrate freely; gases and solids usually dissolve in liquids to a more or less limited extent; liquids may be partly, or wholly, or hardly miscible. One solid will not dissolve in another (setting aside one or two exceptional experiments on "diffusion"), but cooling a mixed liquid will sometimes give us a "solid solution." Sea water, however, like many other solutions, freezes in separate crystals of ice and salt.

A solution in water is exactly the same in nature whether the dissolved substance be a solid, a liquid, or a gas. It is in the finest possible state of subdivision—individual molecules, or in some cases individual electrically charged ions. In all cases, the dissolved substance, with its scattered molecules, behaves very much as a pure gas does in its responses to changes of temperature and pressure—a very important conception due principally to van't Hoff.

If the molecules of the dissolved substance are large, like those of sugar, "sieves" can be devised which do not allow them to pass through, while presenting no obstacle to the smaller molecules of water. If the solute is not volatile, molecules of the solvent water can be driven off by evaporation; in such a case the surface of the liquid acts as a "sieve" of the kind. A controlled and complex "sieve" action is characteristic of the walls of living cells, and of the greatest vital importance. A solution is less ready either to boil or to freeze than a pure liquid.

There is one other state of matter which demands attention: the Colloidal state. Thomas Graham, the discoverer, suggested a division of all substances into "crystalloids" and "colloids"; we now know that nearly all substances can at different times assume both these different forms. A typical colloid, such as colloidal gold or arsenious sulphide, forms a "solution" in water; but this is not a true solution, for the particles are a hundred times larger than molecules; they are large enough to have the properties of surface. Nevertheless, the individual colloidal particles do not clump together and sink; and this is because each one carries an electric charge, and like charges repel each other. In this way the colloidal particles ward each other off; but if electrically charged ions be introduced into the solution (for example, those of common salt), they rob the colloidal particles of their charges, and coagulation and sinking follow. But this is probably too simple an account of a very complex equilibrium. There are other colloids, such as gelatine, whose particles have an additional protection in the form of a surrounding coat of water molecules; these are called "emulsoids" and are much harder to precipitate, unless the defending water-molecules be removed first. If this is done, as it readily can be done by means of such "water-greedy" substances as alcohol, the emulsoid particles have still the same protection as the "suspensoid" particles of colloidal gold: the electric charge. The knight has lost

his coat of mail, but he retains an inborn genius for dodging. The "armoured" particles of emulsoids such as gelatine are sometimes used to protect the more defenceless particles of various suspensoids.

But gelatine does not always exist as scattered particles in water; it can, as everybody knows, "set" in a jelly. This "gel" is just the converse of the other form, or "sol," and consists of scattered droplets of liquid buried in a relatively solid mass. Such a mass can be robbed of some of its water, a loss which it makes good at the first opportunity by imbibing more water and swelling up in the process; but the mass must not be likened to an ultra-microscopic sponge, its hold on the water droplets is far stronger than that. This alternation between solution and jelly, "sol" and "gel," is of the greatest importance in the study of living matter. For proteins, of all classes of organic compounds the most characteristic of life, always present themselves in the colloidal state (perhaps because their molecules are so large as to attain colloidal dimensions), and there is no doubt that a balanced equilibrium between sol and gel is a primary feature in the life of the living cell.

Colloidal particles are too small to be seen, even in the microscope, but they are not too small to interfere with rays of light. Thus they betray their presence as shining dots, continually agitated in "Brownian movement" by the jostling molecules of the water, in the "ultra-microscope." They are small enough to defy gravity when protected by an electric charge. They are large enough to have a surface, and this is of great importance: for there is always a marshalling of molecules at a surface, very favourable to chemical reactions. This is part of the reason why animals and plants, by means of colloidal ferments or "enzymes," are able to carry out chemical processes more swiftly, more smoothly, and more economically, than the chemist with all his armoury of weapons.

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